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SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD

Submitted by the

DIRECTOR OF CENTRAL INTELLIGENCE

The following intelligence organizations participated in the preparation of this estimate: The Central Intelligence Agency and the intelligence organizations of the Departments of State, the Army, the Navy, the Air Force, The Joint Staff, and the Atomic Energy Commission.

Concurred in by the

INTELLIGENCE ADVISORY COMMITTEE

on 12 March 1957. Concurring were the Special Assistant, Intelligence, Department of State; the Assistant Chief of Staff, Intelligence, Department of the Army; the Director of Naval Intelligence; the Director of Intelligence, USAF; the Deputy Director for Intelligence, The Joint Staff; and the Atomic Energy Commission Representative to the IAC. The Assistant Director, Federal Bureau of Investigation, abstained, the subject being outside of his jurisdiction.

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SOVIET CAPABILITIES AND PROBABLE PROGRAMS IN THE GUIDED MISSILE FIELD

THE PROBLEM

To estimate Soviet capabilities and probable programs in the field of guided missiles, including earth satellites, through 1966. [1]

FOREWORD

This estimate supersedes NIE 11–6–54, Soviet Capabilities and Probable Programs in the Guided Missile Field, 5 October 1954, and its supplement, NIE 11–12–55, Soviet Guided Missile Capabilities and Probable Programs, 20 December 1955. Although some new intelligence has strengthened our previous estimate that the USSR has an extensive guided missile program, intelligence on specific guided missile systems continues to be deficient. In making this estimate in a field where positive intelligence is minimal, we have employed three interdependent approaches: military requirements, scientific and technical capabilities, and economic capabilities. Throughout the entire estimative process, the fullest consideration has been taken of the available evidence of Soviet missile activity, US guided missile experience, and known and estimated Soviet capabilities in related fields.

This estimate is based on previous judgments that the USSR does not now intend to initiate general war deliberately and is not now preparing for general war as of any particular future date.

Except where noted otherwise, the operational capability dates given in this estimate are the earliest probable years during which one or more missiles could have been serially produced and placed in the hands of trained personnel of one operational unit, thus constituting a limited capability for operational employment. These dates are based on our estimate that a concerted and continuous native Soviet research and development program began in 1948.

Although considerable effort has been devoted to estimating a Soviet production and operational program for guided missile systems through 1966, the production quantities and time-phasing presented in Annex A represent only a possible Soviet program, but one which is considered both feasible and reasonable. [2]

[1] Unguided rockets are not included in this estimate.

[2] See the Director of Intelligence, USAF, footnote to Annex A, paragraph 1.

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CONCLUSIONS

GENERAL CONCLUSIONS

1. We estimate that the Soviet guided missile program is extensive and enjoys a very high priority. *(Paras. 17, 27, 29–30, 50)*

2. We believe that the USSR has the native scientific resources and capabilities to develop during this period advanced types of guided missile systems, in all categories for which it has military requirements. *(Paras. 29–38)*

3. We estimate that the USSR has the industrial base and related industrial experience to series produce the missile systems it will develop during this period. However, in view of competing demands, the limited availabliity of electronic equipment will seriously restrict the extent and variety of Soviet guided missile production until about 1958. Thereafter, expanding electronics production will probably make this restriction much less severe. *(Paras. 45–48)*

4. We estimate that the USSR has requirements for various sizes of nuclear, high explosive (HE), and chemical (CW) warheads, and has the capability to develop them on time scales consistent with the missiles in which they would be employed. In view of competing demands, the availability of fissionable materials will impose limitations on the extent of Soviet nuclear warhead production during the period of this estimate. *(Paras. 39–42, 54, Annex A)*

SPECIFIC SOVIET CAPABILITIES AND PROGRAMS

Surface-to-Air Missiles

5. We estimate that surface-to-air missile systems have one of the highest priorities among current Soviet military programs. At Moscow, an extensive system of surface-to-air missile sites has been constructed, and all sites are probably now operational. This system can probably direct a very high rate of fire against multiple targets at maximum altitudes of about 60,000 feet and maximum horizontal ranges of about 25 n.m. *(Paras. 27–28, 32, 56–60)*

6. During the period 1958–1961, surface-to-air systems with increased range and altitude capabilities for static defense of critical areas, and with low and high altitude capabilities for defense of static targets, field forces, and naval vessels, could probably become available for operational employment. Sometime between 1963 and 1966, the USSR could probably have in operation a surface-to-air system of some capability against the ICBM. *(Paras. 61–67)*

7. We estimate that series production of surface-to-air guided missiles is now under way in the USSR, and that it will probably produce such missiles in large quantities. Nuclear warheads could now be incorporated into a limited number of surface-to-air missiles. We estimate that some percentage of surface-to-air mis-

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siles will be so equipped during the period of this estimate. *(Paras. 19, 59–60, Annex A)*

Air-to-Air Missiles

8. Despite a lack of significant intelligence, we estimate that the USSR has pursued the development of air-to-air missiles, and that it could now have in operational use a 2–3 n.m. range missile capable of tail-cone attacks in good weather. It is probable that the USSR could have a 5 n.m. all-weather missile operational in 1958 and a 15–20 n.m. all-weather missile, capable of employing a nuclear warhead, in 1960. *(Paras. 68–70)*

Air-to-Surface Missiles

9. In 1955 the USSR could probably have had a 20 n.m. subsonic air-to-surface missile available for operational use. In 1956–1957 a 55 n.m. subsonic missile could probably be available, and there is some evidence that such a missile has reached at least final flight test stage. A 55 n.m. supersonic missile could probably be available in 1958. These missiles, designed primarily as antiship weapons, could also be employed against isolated and well-defined radar targets on land. In 1961, a 100 n.m. supersonic missile could probably be available for employment by heavy bombers. Each of these missile types could employ nuclear warheads. *(Paras. 71–74)*

Surface-to-Surface Ballistic Missiles (up to 350 n.m. range)

10. There is considerable evidence of Soviet development of short-range surface-to-surface missiles, and we estimate that the USSR could probably have had available for operational use in 1954 ballistic missiles with the following maximum ranges: 75 n.m., 175–200 n.m., and 350 n.m. These types could be equipped with nuclear warheads. However, the USSR would probably consider CW warheads desirable for certain specific purposes, and might employ HE in the two shorter-range types. *(Paras. 75–79, 81, Annex A)*

Surface-to-Surface Ballistic Missiles (700 n.m. and 1,600 n.m. ranges)

11. Evidence on Soviet development programs leads us to estimate that the USSR could probably have had a 700 n.m. maximum range ballistic missile available for operational use in 1956. We have firm evidence that in 1949 the USSR was interested in a 1,600 n.m. intermediate range ballistic missile (IRBM), and we believe it is a logical step in the Soviet development program. We estimate that the USSR is developing an IRBM, and that it could probably have such a missile in operation in 1959. Both these missile types would require nuclear warheads, although we do not exclude the possibility of CW use with the 700 n.m. missile for occasional special missions. We believe the USSR would rapidly acquire a considerable number of both the 700 n.m. and the 1,600 n.m. missiles. *(Paras. 80, 82, Annex A)*

Intercontinental Ballistic Missiles (ICBM: 5,500 n.m. range)

12. We have no direct evidence that the USSR is developing an ICBM, but we believe its development has probably been a high priority goal of the Soviet ballistic missile program. We estimate that the USSR could probably have a 5,500 n.m. ICBM ready for operational use in 1960–1961.[3] We believe that the

[3] Date predicated on first operational unit being equipped with prototype missiles.

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USSR will seek to acquire a considerable number of ICBM's with nuclear warheads as rapidly as possible. *(Para. 84, Annex A)*

Submarine-Launched Surface-to-Surface Missiles

13. We believe the USSR would probably have developed cruise-type missiles initially, and there is some evidence pointing to the existence of Soviet submarines equipped to carry such missiles. The USSR could probably have had in operation in 1955 a subsonic turbojet missile capable of a maximum range of 500 n.m., and a supersonic missile capable of this range could probably be in operation in 1957. A supersonic cruise-type missile capable of ranges up to 1,000 n.m. could probably be operational in 1962. These missile types would require nuclear warheads. With a vigorous program, the USSR might achieve an operational submarine-launched IRBM system sometime during the period 1964–1966. *(Paras. 83, 85–89, Annex A)*

Earth Satellite

14. The USSR will probably make a major effort to be the first country to orbit an earth satellite. We believe that the USSR has the capability of orbiting, in 1957, a satellite vehicle which could acquire scientific information and data of limited military value . A satellite vehicle possessing substantial reconnaissance capabilities of military value could probably be orbited in the period 1963–1965. *(Paras. 90–91)*

DISCUSSION

I. SOVIET MILITARY REQUIREMENTS FOR GUIDED MISSILES

15. The Soviet guided missile program necessarily operates within the framework of current and future military requirements laid down by Soviet defense planners. While we have no direct evidence on the elements of this framework as it applies to missiles, we believe it would logically have been based on: (a) an appreciation of the USSR's present and probable future strategic and tactical situations; (b) an estimate of the types of attack that could be launched against the USSR in the foreseeable future; (c) operational requirements for which missile systems could be employed to replace or augment other weapons systems; and, finally, (d) an evaluation of the probable effectiveness of missiles *versus* other weapons systems to perform required missions.

16. The USSR has almost certainly been assisted in determining the scope and priorities of its missile programs by information on Western, including US, military programs. This information is probably complete enough to enable the USSR to judge approximately the time phases in the develoment, effectiveness, size, and composition of US and Allied offensive and defensive forces. Specifically, the Soviet leaders can probably judge such factors as the general size of nuclear stockpiles, the weapons systems into which nuclear warheads have been incorporated, the general progress of air defense programs, and the general characteristics and availability dates of offensive and defensive missiles.

Strategic and Tactical Considerations

17. Certain considerations which have played a role in Soviet military thinking in recent years make it plausible that the USSR should have given a high priority to the development of missiles. The Soviet leaders have heavily emphasized the development of their nuclear capability, and probably also believe that mis-

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siles will ultimately become the primary means of delivery for nuclear weapons. Soviet concern over US and Allied capabilities for strategic air attack has compelled the USSR to place high priority on development of a modern air defense system, in which missiles are now an essential ingredient and will ultimately become the primary weapon. Finally, the relative geographic disadvantages faced by the USSR for purposes of strategic attack, due to US possession of a forward base structure on the Soviet periphery, could be offset to some degree by development of long-range missiles for delivery of nuclear weapons. All these factors probably figured in a Soviet decision, taken early in the postwar period, to make a major effort in the development of guided missiles.

Soviet Requirements for Defensive Missile Systems

18. In preparing their requirements for air defense guided missile systems, Soviet military planners would probably have constructed a picture of the time-phased threat from existing and foreseeable Western offensive weapons systems about as follows:

- *In 1956:* high and low altitude bombing attack by aircraft flying at subsonic speeds and at altitudes up to 55,000 feet; in peripheral areas, attack by short and medium range cruise-type missiles; where ground forces would be in contact, attack by short range ballistic missiles.
- *By 1961:* attack by aircraft employing air-to-surface missiles; bombing attack by aircraft capable of supersonic "dash" and altitudes up to 65,000 feet; attack by long range cruise-type missiles capable of high subsonic speeds and altitudes up to 60,000 feet; attack by long range ballistic missiles.
- *By 1966:* attack by supersonic aircraft and cruise-type missiles, capable of altitudes on the order of 80,000 feet; attack by long range ballistic missiles.

19. The USSR would have proceeded on the assumption that high-yield nuclear weapons or warheads could be incorporated into any of the Western weapons systems described above. This assumption would dictate a requirement for air defense missile systems with a high kill probability, and therefore the inclusion of a percentage of nuclear warheads in Soviet air defense missile systems at an early date.

20. Soviet defense planners would probably have formulated generalized operational requirements for both surface-to-air and air-to-air systems capable of countering the threat outlined above. Surface-to-air requirements would probably have included static and mobile systems for the defense of critical governmental and industrial centers, important military centers and bases, major naval forces afloat, and major units of the Soviet Army. Operational requirements for air-to-air missile systems would probably have been based on the need to increase the kill capabilities of existing and projected Soviet interceptors.

21. Our intelligence on Soviet development of surface-to-air missiles to date indicates that time-phased Soviet operational requirements probably began with a point-defense system capable of interdicting bomber aircraft at altitudes up to about 60,000 feet. Our estimate of the Soviet analysis of the foreseeable threat indicates that Soviet requirements for air defense missiles over the next few years would become much more exacting, including longer ranges, higher speeds, and more technically advanced guidance systems. Later in the period, a high-priority requirement would emerge for a system capable of a high kill probability against ballistic missiles.

Soviet Requirements for Offensive Missile Systems

22. In preparing their requirements for offensive missile systems, Soviet military planners probably would have developed generalized operational requirements for systems in both the surface-to-surface and air-to-surface categories. Available intelligence supports our belief that the USSR has had considerable interest in both these categories, especially in a family of surface-to-surface ballistic missiles.

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23. Soviet requirements for shorter range surface-to-surface missiles would probably have been derived from the military missions of attacking targets in direct tactical support of field forces, and of attacking other targets of importance in a military campaign. Such requirements would probably have been derived as follows:

a. Soviet requirements for surface-to-surface missiles for tactical support of field forces would have been derived in general from the missions of various echelons of the Soviet Army. From current Soviet tactical doctrine we deduce that operational requirements would probably have been developed for ballistic missiles of up to 75 n.m. range for support of division and corps operations, up to 200 n.m. range for support of field armies, and up to 350 n.m. range for support of army "fronts." [4]

b. Similarly, Soviet requirements for these shorter range surface-to-surface missiles for the support of other operations and for the neutralization of certain additional targets of broad strategic significance would have stemmed from target systems including a variety of key installations of both tactical and strategic significance. A family of 75,200, and 350 n.m. missiles would probably have been developed to provide coverage for these targets systems.

c. In addition, a requirement might have been developed for a ballistic or cruise-type missile capable of a longer range, both for support of certain army "front" operations and for the neutralization of certain additional targets.

24. Considering the ranges from possible launching sites within the Bloc to targets on or near the Eurasian land mass, Soviet planners would probably have developed requirements for longer range surface-to-surface missiles: (a) ballistic missiles of 600–900 n.m. maximum range and of longer ranges up to 1,600 n.m. for peripheral attack missions, including the neutralization of US and Allied bases and attack on strategic targets in non-Bloc nations on the Eurasian periphery; and (b) a ballistic missile capable of up to 5,500 n.m. range, for intercontinental attack. The possibility exists that interim Soviet surface-to-surface missile requirements might have included cruise-type missiles in one or more of the foregoing range categories. Requirements for specialized naval versions of both cruise-type and ballistic missiles, suitable for launching by submarines or surface vessels, would probably also have been developed.

25. It is reasonable to infer that the USSR would have developed requirements for air-to-surface missiles to overcome foreseeable improvements in the capabilities of land and shipborne air defense against bombardment aircraft. Generalized operational requirements would probably have included a missile of at least 100 n.m. range to augment the capabilities of long-range bombers against heavily-defended land targets and large naval concentrations, as well as shorter range missiles for employment against single ships or other isolated and well-defined radar targets.

26. Soviet military planners may also have considered that a requirement existed to develop certain missiles for specific functions in the field of countermeasures against Western air defense systems. Such a requirement could include surface-to-surface cruise-type missiles and air-to-surface missiles, equipped with ECM gear, to be employed as decoys to saturate air defense radar and control systems. In addition, it could include air-to-surface missiles capable of homing on and destroying ground radar installations.

Soviet Evaluation of Missiles *Versus* Other Weapons Systems

27. Soviet military planners, having established generalized operational requirements for which guided missile systems could be employed, would probably then have evaluated the effectiveness of missiles *versus* other weapons systems to perform the missions of air defense, tactical support, peripheral attack, and intercontinental attack. Based in part on the limited intelligence available on current Soviet military programs, including the

[4] A Soviet army "front" is roughly comparable to a US army group.

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missile program, we believe that the Soviet evaluation was as follows:

a. Air defense. The most immediate and greatest Soviet military concern is the safeguarding of key Soviet strengths and centers of control. In the face of the grave threat from Western, especially US, air-nuclear forces in being and programmed, Soviet air defense kill probabilities must be brought to a much higher level at a very early date. Conventional antiaircraft artillery is a weapons system of negligible value against high performance, high altitude bombardment aircraft, although this system will continue effective for at least a few years against attack by aircraft at lower altitudes. Fighter aircraft with conventional armament will continue to be effective for a few years against many of the likely forms of air attack on the USSR, but can achieve maximum effectiveness against high-performance, high altitude attack only if fitted with air-to-air guided missiles. As the period advances, improving capabilities of both defending and attacking aircraft, and of attacking cruise-type missiles, will dictate more exacting operational requirements for air-to-air missiles. When supersonic cruise-type or ballistic missiles constitute the major threat, the operational requirement for air-to-air missiles will tend to phase out. Guided missile systems offer the best promise of raising the effectiveness of Soviet air defenses to an acceptable level.

b. Tactical support. The Soviet Army ground forces have been reorganized and modernized since the end of World War II, and for the past three years their unit organization has been undergoing further changes to meet the requirements of modern warfare, nuclear or non-nuclear. Current Soviet tactical doctrine emphasizes allocation of nuclear weapons for use against enemy defensive positions, air facilities, reserves, nuclear capabilities, and encircled enemy units. This same doctrine envisages the use of artillery, guided missiles, and tactical aircraft as nuclear delivery means. Most Soviet requirements for direct support of line divisions can now be met satisfactorily with field artillery, unguided rocket artillery, and aircraft. However, guided missiles offer certain advantages over tactical aircraft, and should be programmed to augment and to some extent replace the latter.

c. Peripheral attack. Among the essential elements in Soviet strategy for the initial phase of a general war are the destruction or neutralization of Western nuclear capabilities wherever deployed, destruction of ready NATO forces, prevention of NATO's full mobilization, and isolation of the European theater by interdicting US reinforcement of overseas forces. Soviet tactical and naval aviation, augmented by units of long-range aviation, will be suitable for some time for carrying out attacks on the Eurasian periphery. A submarine-launched guided missile could be an important weapon system for this mission. Although conventional air attack will remain effective for some time, a substantially improved capability could be attained with air-to-surface missiles. For peripheral attack generally, and base neutralization in particular, ballistic missiles carrying nuclear warheads, by imposing maximum surprise and difficulty of interception, could ultimately present a greater threat to Western targets than any other Soviet weapons system.

d. Intercontinental attack. To deter the US from initiating general war against the Bloc and to fight such a war successfully should it occur, the USSR requires a powerful intercontinental nuclear striking force. This force should be capable of neutralizing US nuclear delivery capabilities at the outset, and of inflicting damage of a decisive nature on other continental US targets. There will be a period of years during which the USSR probably will rely principally on the manned bomber for adequate coverage of targets in the continental US, although the Soviet geographic disadvantage, as well as existing US air defenses and foreseeable improvements, will continue to handicap manned aircraft in the execution of the intercontinental attack mission. A decrease in the vulnerability of attacking aircraft can be effected by equipping them with air-to-surface missiles. Submarine-launched missiles could be an important weapon system for attacks against appropriate targets in the US. Nevertheless, in the long run, improving US early warning and

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defense capabilities could render even these attack capabilities insufficient. The intercontinental ballistic missile (ICBM), however, could enable the USSR to present an entirely new type of threat, against which adequate defense, while scientifically possible, would be most difficult.

Priorities within the Soviet Guided Missile Program

28. In determining priorities for its program of missile development and production the USSR would have taken into account the following main factors: (a) priority of missions to be carried out (i.e., first priority to air defense, second to peripheral and intercontinental attack, third to tactical support); (b) comparative value of missiles *versus* other weapons systems, and of one missile type *versus* another, in carrying out these missions; (c) feasibility of developing a particular missile or missile system in time to meet requirements; (d) availability of resources to develop and produce various types of missiles, including associated equipment and warheads. Taking these factors into consideration, we estimate that at some time in the past Soviet military planners established priorities within their guided missile program generally as indicated below. While we believe that such a system of priorities is probably governing the Soviet guided missile program at the present time, we recognize that it will be subject to continuing revision as Soviet programs for the development of missiles and other weapons systems advance, and as the USSR reappraises its military requirements.

High Priority

a. Missiles which can be developed in a short time:
1. Surface-to-air, HE
2. Air-to-air, HE

b. Missiles which can be developed in a longer time:
1. Surface-to-surface, peripheral attack, nuclear
2. Surface-to-air, improved, nuclear/HE
3. Air-to-surface, land targets, nuclear

c. Missiles which can be developed in a very long time:
1. Surface-to-surface, intercontinental attack, nuclear
2. Surface-to-air, antimissile missile, nuclear

Lower Priority

a. Missiles which can be developed in a short time:
1. Surface-to-surface, tactical support, nuclear/HE/CW
2. Surface-to-surface, submarine launched, nuclear
3. Air-to-surface, ship targets, nuclear/HE

b. Missiles which can be developed in a longer time:
1. Air-to-air, improved, nuclear
2. Air-to-surface, improved, ship targets, nuclear

In addition, an earth satellite with limited instrumentation for scientific purposes has probably been assigned a high priority for development in a short time. A satellite vehicle possessing reconnaissance capabilities of military value has probably been assigned a lower priority for development in a very long time.

II. FACTORS AFFECTING SOVIET GUIDED MISSILE CAPABILITIES

Scientific and Technical Capabilities

29. On the basis of considerable evidence, we are confident that the Soviet missile research and development program is extensive and enjoys a very high priority. Although the USSR had no known guided missile development program during World War II, it initiated such a program at the close of the war with a thorough and systematic exploitation of German missile experience. A native Soviet program has advanced rapidly since about 1948, and at present it embraces high quality research institutes, design bureaus, and plants, including some of the best facilities and equipment available in the USSR. These resources are adequate to continue and to expand the missile program. We believe

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that the USSR need not in the future depend to any major extent upon Satellite support, except possibly in certain narrow fields such as precision optics and electronic instruments.[5]

30. The large number of Soviet activities associated with missile development, as well as results known to have been achieved to date, provide clear evidence of the intensity of the program, but there is relatively little information on its details. Our assessment of Soviet scientific and technical capabilities to develop missile components (presented in this section) and to develop complete missile systems (presented in Section III) is based wherever possible on the limited intelligence available, including information obtained from returning German missile specialists. However, we have also relied in large measure on known or estimated Soviet capabilities in relevant technical fields, and on US guided missile experience.

Missile Guidance and Control

31. The foundation for current Soviet capabilities in missile guidance is largely postwar exploitation of German personnel, facilities, equipment, and documents. The reconstruction, design improvement, and, in some cases, testing of German equipment by German specialists in the USSR covered almost the entire spectrum of guidance concepts in the surface-to-surface missile category, including radar tracking-radio control, beam riding, inertial, and celestial guidance systems. In the surface-to-air category, the USSR acquired enough German knowledge and equipment to reconstruct the *Rheintochter, Schmetterling,* and *Wasserfall* missiles, each of which included an optical track-radio command system. An air-to-air guidance system for the *Sokol* missile, utilizing the same principles, was advocated by the Germans in the USSR. The electronic analogue computer of the *Wasserfall* system was subjected to further detailed studies and design improvements. The Germans also designed a surface-to-air missile system designated the R–113. The guidance proposed for this system was a two-radar, ground based, command control type, capable of 360° coverage in azimuth. One radar was to acquire and track the target, and information from this radar was to be fed through a computer to the second radar which was used to track and position the missile. A semiactive radar homing head, also worked on by German scientists, appears to have been designed for use in a *Wasserfall* or R–113 type missile. The USSR exploited German World War II infrared developments, including a missile homing head called *Juno.* In the air-to-surface category, the Germans worked on a guidance system designated *Komet*,[6] which was a combination beam rider and semiactive homing system. Beginning in about 1948, the USSR apparently reached the point where it could largely dispense with German assistance, except in the missile guidance field. We have no information on German activities in the USSR subsequent to 1954.

32. Firm evidence has not been obtained to indicate which of the many guidance systems are being utilized in Soviet missiles. In the surface-to-air and air-to-surface categories, however, there are some fragmentary data:

a. The air defense launching sites around Moscow employ a unique guidance system of native Soviet design. This system apparently has the ability to track multiple targets while scanning for new targets. It also apparently has an ability simultaneously to control multiple missiles against multiple targets. Recent information indicates that a command guidance system may be employed. However, the possibility of a combination command-seeker system has not been ruled out. Several years' work on a semiactive surface-to-air homing system, performed by a German group, might have been intended to complement the ground guidance system associated with the Moscow sites.

b. In the air-to-surface category, there is some evidence that the USSR continued development of an antishipping guidance sys-

[5] Detailed information on Soviet scientific and technical resources for guided missile development, including the availability of technical information from foreign sources, is presented in Annex B.

[6] For purposes of identification in US intelligence, the designation *Komet* refers not only to this guidance system, but also to the complete missile system employing it.

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tem closely resembling the German *Komet*. Electronic signals emanating from the Black Sea region were intercepted on many occasions in 1955 and again in late 1956. These signals were quite similar in many technical characteristics to the signals a *Komet* system might have radiated.

33. In addition to the fragmentary information presented above, a strong inferential measure of Soviet success in the guidance and control area is the large-scale ballistic missile test program which has been under way at Kapustin Yar.[7] Considering the above evidence in conjunction with demonstrated Soviet capabilities in other electronics applications, we conclude that the USSR possesses the necessary scientific knowledge and technical skills to develop advanced guidance and control systems for all categories of guided missiles.

Missile Propulsion

34. As in the missile guidance area, the USSR took energetic measures after World War II to improve its knowledge of propulsion systems for guided missiles. Only in the field of solid propellants, where the USSR had achieved a position of world leadership during World War II, was its interest in German work limited. The USSR acquired large quantities of pulsejet and rocket engine parts, assemblies, and production tooling from Germany. Both standard and improved versions of V–1 and V–2 engines were produced under German supervision. Some reports indicate that as many as 100 to 300 V–2 motors of 25 tons thrust[8] were completed during the period 1947–50. The Germans also developed an improved V–2 engine with a thrust of 35 tons. This motor was placed in production in late 1948 and 100 to 250 had reportedly been produced by 1950. At Soviet direction, two groups of Germans also worked on designs for two different 100-ton thrust motors, one of which was to be gimballed for missile directional control. Other evidence indicates that a 100-ton thrust motor could have been ready for static test in 1952; this would represent an outstanding achievement in advanced technology. In the surface-to-air category, design improvements were made on the *Wasserfall* motor to increase its thrust from 17,000 pounds to approximately 20,000 pounds. We have some evidence of Soviet work in ramjet engines, but we know of no Soviet application of such engines to guided missiles.

35. Known Soviet achievements in turbojets and in both solid and liquid rocket motors indicate that the USSR is well advanced in propulsion systems applicable to guided missiles. Evidence indicating the application of turbojets to missile propulsion is lacking.

Aerodynamics and Structure

36. We have no information on aerodynamic developments in the USSR which can be associated directly with the missile program since 1950. Most of the German work dealt with ballistic missiles. Many structural design modifications of the V–2 were made, including light weight structure and pressurized, integral fuel tanks. One structural design (the R–14 ballistic missile) differed radically from the V–2. It had a long cone-shaped body with no aerodynamic control surfaces; control was provided by a gimballed motor. New body designs were also provided by the Germans in the surface-to-air category, including the R–113 missile, which was longer and slimmer than the *Wasserfall* and had two wings and three tail surfaces instead of a cruciform configuration.

37. We do not know that any German designs have been developed fully by the USSR. Native Soviet activity in the design field is indicated by a single German report of a Soviet design for a subsonic air-to-surface *Komet* missile.

38. The USSR is known to have a number of the world's outstanding aerodynamicists, particularly in the field of theoretical areodynamics, supported by extensive research facilities. Despite the dearth of information on native Soviet missile air-frame design, we estimate that the USSR has the knowledge of

[7] For details of Soviet ballistic missile test firing activities, see Annex C (Limited distribution under separate cover).

[8] *Metric* tons are used throughout this estimate.

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basic aerodynamics, as well as the personnel and facilities, to support a program for development of guided missiles of transonic and supersonic speeds.

Warheads and Fuzes [9]

39. The USSR did not intensively exploit German World War II explosives experience, probably because a high level of native competence in explosive and fuze technology had already been achieved. To a limited extent, however, the USSR did acquire information on German fuzing techniques, equipment, and data, exhibiting interest in the V–2 fuzing system and in electromagnetic fuzes for missile warhead application. We have extremely limited knowledge concerning the native Soviet program of warheads and fuzes. Impact, time-delay, or proximity fuzing techniques would not present any insurmountable technical problems to the USSR.

40. Although we have some evidence on the details of the Soviet chemical warfare (CW) program, there is no evidence of the application of CW materials to guided missiles. We estimate, however, that the USSR is currently capable of providing CW warheads for any missile intended for antipersonnel attacks. Our estimate of Soviet capabilities to develop and produce nerve agents and an examination of the problems involved in the dissemination of agents in missile warheads leads us to believe that the USSR could have had tabun (GA) warheads in 1954, and sarin (GB) warheads in 1956. We estimate that the USSR could probably develop and employ "V" agents, more toxic than the "G" series, in guided missiles by 1960. This date is predicated on Soviet solution of the problem of generating a proper aerosol for dispersal of the "V" agent.

41. As in the case of CW, we have some evidence of a Soviet biological warfare (BW) capability but no evidence of Soviet application of BW materials to guided missiles. We estimate, however, that the USSR is capable of providing BW agents for antipersonnel, anticrop, or antilivestock use as soon as appropriate missiles are available.

42. We estimate that the USSR could now have nuclear warheads for incorporation into several types of guided missiles.

Geodesy and Cartography

43. The accuracies of Soviet long-range guided missiles will depend in part upon the USSR's capabilities in geodesy and cartography. The large, modern geodetic and cartographic organization created by the USSR since the days of Lenin is already notable for its achievements. It has computed a new ellipsoid, resurveyed and greatly extended the first-order triangulation net, and completely readjusted the Soviet survey system to a single datum. Such achievement is possible only by maintenance of very high standards of accuracy. Most of the USSR is now covered by maps at the scale of 1:100,000 and maps of larger scales (1:25,000 or larger) are now being emphasized. The new Soviet geodesy specifications emphasize the pursuit of still greater refinement and accuracy.

44. We estimate that the USSR can achieve geodetic location of targets in the US relative to launching sites in the USSR with errors of 300–500 feet, provided, as we believe, a tie has already been made covertly between Soviet and North American triangulation across the Bering Strait. If this connection has not been made, the probable error in target location would be about 1,000 feet. The location error for European targets is estimated at 200–300 feet. We estimate that by 1965 these errors can be reduced by about half through extension of the Soviet geodetic and mapping system into Satellite areas and through the use of improved intercontinental ties with Europe and North America. The USSR is also working energetically in the study of geodetic gravimetry, wherein gravity measures are used to reduce the error in calculating the relationship of two points on the earth's surface. The high competence of Soviet gravimetrists and their energetic data collection program, especially in the Arctic, may also enable the USSR to make early advances in

[9] Detailed estimates on Soviet capabilities and requirements for warheads are presented in Annexes A and D (the latter in limited distribution under separate cover).

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the study of the extent to which surface gravity variations influence a ballistic missile during flight. There is evidence that the USSR is engaged in the study of the vertical gradient, but information is not available on the details and extent of such work.

Soviet Industrial Capability to Produce Guided Missiles

45. We estimate that the USSR has the industrial base and related industrial experience to adapt and series produce developed prototype missile systems of all types. However, we believe that in view of competing demands, the limited availability of electronic equipment will seriously restrict the extent and variety of Soviet guided missile production until about 1958. Thereafter, expanding electronics production will probably make this restriction much less severe.

46. We estimate that approximately two-thirds of the current output of Soviet electronics production (in value terms) is allocated to military programs, and that the remainder is shared approximately equally by essential domestic telecommunication application and civilian consumer goods. Both the announced plans for the Soviet economy and our estimate of over-all Soviet military requirements indicate an increasing demand for electronics production during the next five years.[10] The Soviet Sixth Five-Year Plan (1956–60) calls for expansion of electronics production by 1960 to three times the value of 1955 production. This increase is one of the largest planned for a major industrial sector, but we estimate that the USSR is capable of realizing this ambitious goal.

47. Other military demands upon electronics output, as well as essential nonmilitary demands, will probably restrict the rapid build-up of missile production until new investment in the electronics industry scheduled under the Sixth Five-Year Plan makes additional output available. We estimate that significant portions of the additional electronics plant capacity will not be available until about 1958. In the interim, the USSR could divert electronics output to missiles from the sizeable residual of nonmilitary electronics production or from other military electronics programs, but it probably would not be willing to accept the adverse consequences of such a reallocation. However, we estimate that the Soviet program for expanding electronics production will create by the later years of the Sixth Five-Year Plan an industrial capability to support an extensive and varied guided missile production program as part of a balanced over-all military program.

48. Another potential bottleneck in the production of guided missiles is the amount of time necessary to train production personnel and to adapt prototype mechanisms to series production. This problem is particularly acute in the production of precision mechanisms for missile system components, such as gyros, stable platforms, mechanical computers, and certain valves. However, we estimate that the USSR has the engineering ability to overcome this potential bottleneck, and that it should be able to produce precision mechanisms in sufficient quantity to support an extensive missile production program.

III. SOVIET GUIDED MISSILE DEVELOPMENT PROGRAM[11]

49. Current intelligence on the specific guided missiles actually under development in the USSR is almost nonexistent, except in a very few instances. In the succeeding paragraphs, therefore, we assess Soviet technical capabilities to develop specific missiles types which, among the vast number of types the USSR could develop, seem to us most likely to satisfy the general requirements outlined in Section I above. There is intelligence to indicate that certain missiles are under development

[10] See also NIE 11-4-56, Soviet Capabilities and Probable Courses of Action Through 1961, 2 August 1956, Sections III–IV.

[11] While we consider the development program as a whole to be probable, the detailed characteristics represent a logical growth or developmental pattern within a particular family of missile systems. We have high confidence in our estimates on certain missiles currently in various stages of development, test, or operational employment. However, in the light of inadequate evidence pertaining to other missile systems, our estimates of detailed characteristics for such systems are less certain.

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or in operation. In most instances, however, and especially for those types estimated for late in the period, our chief guide is our estimate of Soviet requirements and development priorities. Within each broad category of missiles (e.g., surface-to-air), we have presented what we believe is a logical, step-by-step development program toward the more advanced types.

50. This assessment of Soviet capabilities to develop specific missile types is predicated upon our estimate that concerted and continuing native Soviet research and development in the guided missile field began in 1948. The date given as the estimated Soviet operational capability for each missile type is the earliest probable time at which one or more series produced missiles could have been placed in the hands of trained personnel [12] in one operational unit, thus constituting a limited capability for operational employment. We estimate that the time interval between the Soviet decision to produce in series and the attainment of first operational capability is probably between six and 18 months, under average conditions. For convenience, in the succeeding paragraphs we assume that in general a Soviet decision to produce a particular missile in series has preceded the estimated operational date by an average time of one year. However, in instances of very high priority, the USSR could probably reduce this time interval to zero if the first operational unit were equipped with prototype weapons and if personnel training were begun early enough. These instances are specifically noted in the case of the surface-to-air missile (para. 60) and the ICBM (para. 84).

51. Based on our current knowledge of the state of the guided missile art and our estimate of Soviet capabilities in parallel fields, we estimate that when a particular missile system first becomes operational its system reliability will be 40–60 percent. [13]

52. Despite the obvious difficulties of estimating individual weapons types to be developed over a period reaching 10 years into the future, we have sufficient confidence in the estimates made in this section of the paper to characterize the development program in the aggregate as "probable." There are several factors which contribute to this confiddence, including: (a) sufficient intelligence to indicate at least the general nature of some current Soviet missile programs, notably the surface-to-surface and surface-to-air programs; (b) foreseeable developments in US offensive and defensive capabilities which the USSR can ascertain and must attempt to counter; (c) the probability that the ultimate goal of the Soviet development program in the surface-to-surface category is an ICBM, and in the surface-to-air category an anti-ICBM; and (d) the probability that any development program will be limited by foreseeable states of the art and will advance through logical steps. In addition, sufficient technical differences exist between the specific missiles in this development program so that cancellation of one or several of the projects probably would not appreciably advance the operational dates of others.

53. Nevertheless, we recognize that Soviet requirements and priorities could change the development program significantly as the period advances, and new goals, either more ambitious or more restricted, may be set. This would be particularly likely in the event of an unforeseen technological breakthrough.

Warhead Selection [14]

54. As a critical portion of our estimate of the Soviet guided missile development program, we have considered Soviet capabilities to develop warheads for specific missile types. We estimate that the USSR has requirements for various sizes of nuclear, HE, and CW warheads, and has the capability to develop them on time scales consistent with the missiles in which they would be employed. Our selection of appropriate warheads for various mis-

[12] Military personnel or civilian scientists and technicians.

[13] "System reliability" in this context means the percentage of missiles which function according to specifications from missile takeoff to detonation in the target area. Malfunctions prior to launching are not included in this definition of system reliability.

[14] For details, see Annexes A and D (the latter in limited distribution under separate cover).

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sile types, presented in Table I following Section III, is based on estimated Soviet warhead design technology and on consideration of the CEP's, payload weights and probable employment of the various missiles. In general, we believe nuclear warheads would be preferable in most missile types and mandatory in some. The USSR would probably consider CW warheads desirable in some missiles for certain specific missions. HE warheads would be satisfactory in some missiles with relatively small CEP's. We do not believe the USSR would develop and produce BW warheads for guided missiles, since BW could be disseminated more effectively by a wide variety of other means, including clandestine delivery.

Surface-to-Air Missile Systems

55. In 1945–46, the USSR exploited in Germany all the important German surface-to-air missiles under development, including *Wasserfall, Schmetterling,* and *Rheintochter,* and caused a new design *Fluse,* to be undertaken. After their transfer to the USSR, the Germans continued work on these missiles, with the exception of the *Fluse.* Some work was probably done into 1951 to design a semi-active homing head for the *Wasserfall,* and four models are believed to have been constructed and taken over by the USSR in late 1950. Considerable interest was also evidenced by the USSR in improving the capability of the *Wasserfall* computer. In 1950, a group of Germans were ordered to prepare a study on an advanced surface-to-air missile, designated the R–113. Some of the *Wasserfall* features, such as the propulsion system, were to be retained and improved, while other components, notably the airframe, were to be redesigned. Operationally, the R–113 was to be effective at altitudes of from 15,000 to 100,000 feet with a 32 n.m. slant range and a burnout velocity of more than Mach 3. The Soviet specifications for the R–113 were rigorous and more closely supervised than were those of other German design projects. The German design study for this missile was submitted to the Russians in 1951, but its disposition is not known.

56. The most significant current intelligence in the surface-to-air category deals with guided missile installations around Moscow. Sightings of these installations have been made since mid-1953; there have also been a few reports of similar sites being constructed around Leningrad in 1955 and 1956.

57. In the Moscow area, 24 sites have been located with sufficient accuracy to indicate their arrangement in two concentric rings with radii of approximately 25 and 45 n.m. from the center of the city. The circumferential distance between the sites is about 8 n.m. on the outer ring and about 7 n.m. on the inner ring. Observation in all sectors around Moscow has not been possible, but we calculate that the inner ring contains 23 sites and the outer ring 34 sites, for a total of 57 sites. A typical site measures approximately one mile by one-half mile, with three longitudinal and about 11 transverse concrete roads and approximately 60 launching positions. Associated building complexes are of sufficient size to house from 200 to 400 personnel at each site. The dimensions, configuration, disposition, and quality of construction of these installations indicate that they comprise a static guided missile air defense system. [15]

58. Certain unique equipment, designated in US intelligence as "YOYO," is located approximately one mile from each operational site, on the Moscow side, and is generally aligned with the center longitudinal road. YOYO is a radar for use in the surface-to-air missile guidance system. A recent report indicates that in tests in 1952, this radar was employed to track 5–6 targets simultaneously, and that it may be intended to track as many as 25 targets simultaneously. Based on this intelligence, and on the fact that provision has apparently been made for the simultaneous launching of an undetermined number of missiles from each site, we estimate that this system has a high traffic-handling capability.

59. Missile-like objects were observed in substantial numbers at one Moscow site in 1955. They are estimated to be about 2½ to 3 feet in diameter and 25 to 35 feet in length.

[15] See map and diagrams on following pages.

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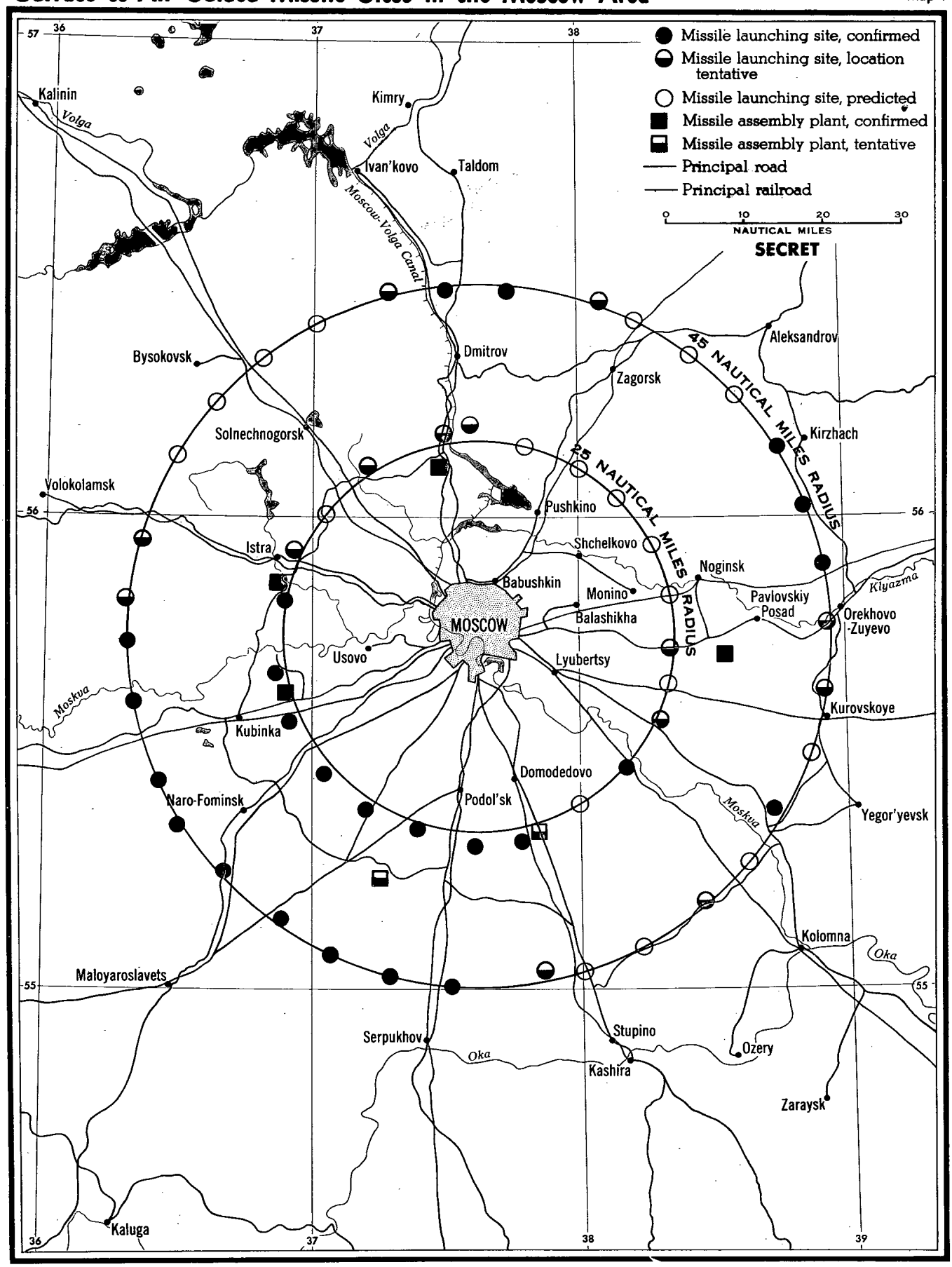
SECRET

Surface-to-Air Guided Missile Sites in the Moscow Area

Map 1



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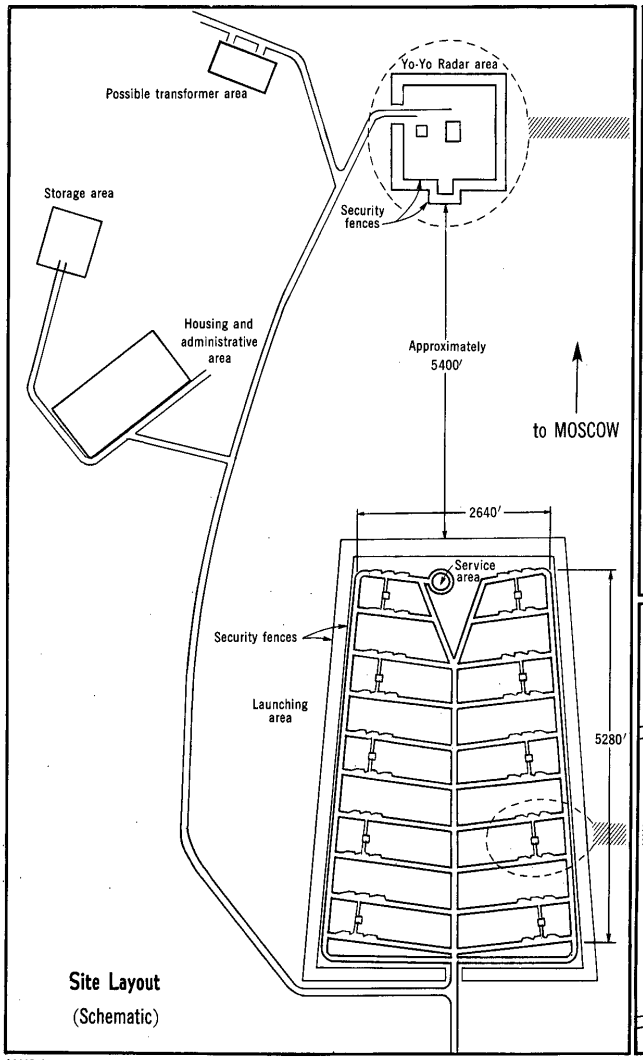
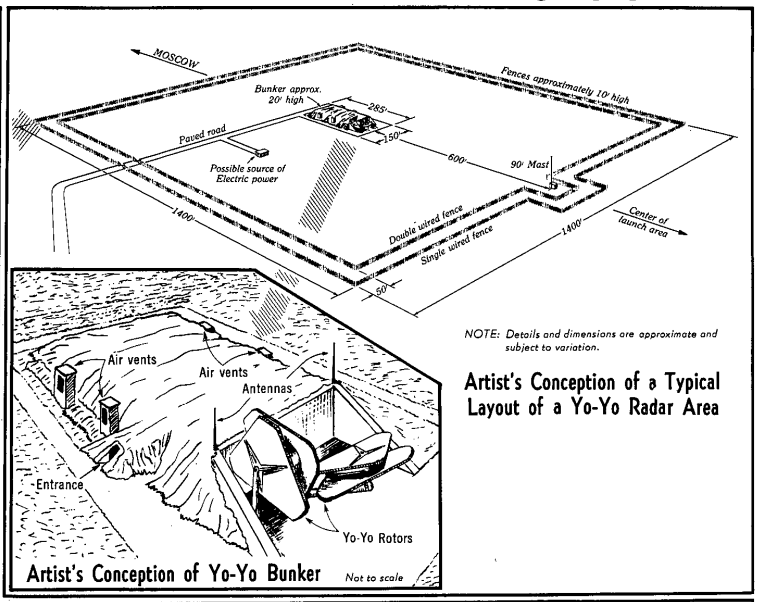
Map 2

Typical Surface-to-Air Guided Missile Site, Moscow Area

TOP SECRET

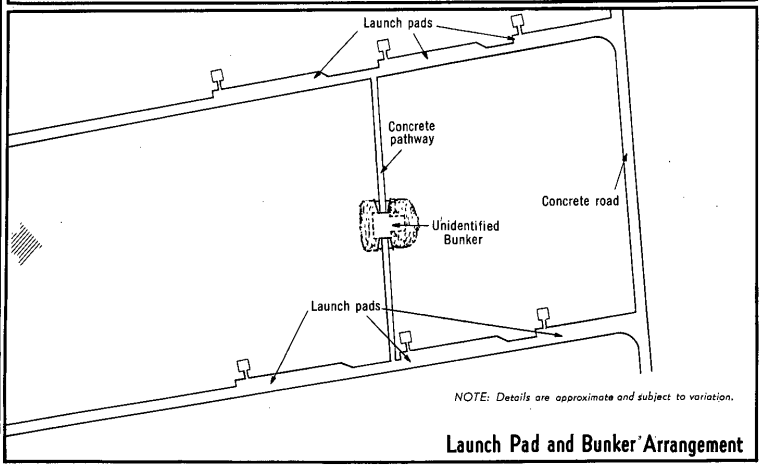


Site Layout
(Schematic)



NOTE: Details and dimensions are approximate and subject to variation.

Artist's Conception of a Typical Layout of a Yo-Yo Radar Area



NOTE: Details are approximate and subject to variation.

Launch Pad and Bunker Arrangement

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60. We believe that some sites in the surface-to-air missile defense system around Moscow have been operational since mid-1955, and that all sites are probably now operational. Based on the size and configuration of the missile-like objects observed, and on technical assessment of the capabilities of the YOYO, we estimate that at present this system probably employs missiles capable of carrying a 600–700 pound payload [16] to a maximum altitude of 60,000 feet, and a maximum horizontal range of 25 n.m. [17] Its guidance system is probably of the command type, with a CEP at maximum range of about 190 feet, or possibly a command and semiactive seeker with a CEP of about 50 feet. We believe that in this instance, the high priority requirement for improved air defense capabilities probably dictated the equipping of the first operational unit with prototype missiles simultaneously with the decision to begin series production.

61. The USSR has an excellent capability for the development of more advanced surface-to-air systems, and a high priority will almost certainly continue to be given to this program. It is probable that the currently operational surface-to-air missile system can and will be improved. We estimate that in 1957 a command-type guidance system capable of 360° traverse could be available for employment with Moscow-type missiles, but that such a system would have a lower traffic-handling capability than the current Moscow system.

62. The current Moscow system will probably continue to have only limited effectiveness at very low altitudes. To overcome this deficiency, it is probable that the USSR will develop and could have in operation in 1958 a surface-to-air system for low altitude coverage, effective to a maximum of 40,000 feet altitude and 15 n.m. range. This system could probably employ missiles carrying 150 pound payloads, and achieve a CEP of about 50 feet with semiactive homing guidance. [18]

63. It is also probable that the USSR will develop and could have in operation in 1959 a surface-to-air system capable of carrying a 500–800 pound payload to a maximum of 80,000 feet altitude and 50 n.m. range. Its guidance would probably be of the command type or a command-seeker combination. The former could probably achieve a CEP of about 500 feet, the latter about 100 feet.

64. Although we have no firm evidence of Soviet interest in surface-to-air missiles for shipborne defense, we believe a requirement for such missiles exists. We estimate that the USSR could probably have a 40,000 ft/15 n.m. missile system in operation in 1958, and an 80,000 ft/50 n.m. missile system in operation in 1960. We also estimate that the USSR could modify either or both of these missiles so as to make them suitable for dual purpose use as surface-to-surface missiles in appropriate naval roles. Recognizing that a high degree of accuracy would be dependent upon the ability of the launching ship to acquire targets by radar, we estimate that the maximum effective range of the 80,000 ft/50 n.m. system against surface targets would be roughly 30–50 n.m.

65. For improved range capabilities in defense of critical areas, it is probable that the USSR will develop and could have in operation in 1961 one of two missile systems: (a) a ramjet propelled missile capable of carrying a 500-pound payload to a maximum altitude of 60–80,000 feet and a maximum of 100 n.m. Such a missile would have a speed of about Mach 2.5 and a CEP of 100 feet with terminal homing or 500 feet with command guidance; (b) a rocket-propelled missile capable of the

[16] Payload includes the explosive device and its associated fuzing and firing mechanism. For the estimated yields of nuclear payloads which could be employed in these and other missiles see Annex D (Limited distribution under separate cover).

[17] This range represents our estimate of Soviet capabilities to extend the maximum horizontal range of the system. It probably had a maximum horizontal range of 20 n.m. when it first became operational in 1955.

[18] It is the view of the Director of Intelligence, USAF, that the USSR would be unlikely to have an effective all-weather land based low altitude surface-to-air missile system in operational use prior to 1960–61. There is no evidence of Soviet interest in, or development programs for such a system. Further, the advanced radar techniques required for an operational guidance and homing system for such a missile are probably beyond the capability of Soviet electronic technology prior to 1960–61.

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same payload capacity, accuracy, and range, but with an altitude up to 90,000 feet and a speed of about Mach 4. We estimate that the latter would probably be the USSR's selection, although the development of such a system would present more complex problems than the development of a ramjet missile system.

66. The required performance characteristics of a surface-to-air missile system which could effectively engage both supersonic cruise-type missiles and ICBMs are not fully known. Required engagement characteristics are estimated as 75 n.m. horizontal range and 300,000 feet altitude to oppose the ICBM, and 300 n.m. horizontal range and 90,000 feet altitude to oppose cruise-type missiles. We do not believe a single system effective against both these targets at maximum range and maximum altitudes could be developed by the USSR during the period of this estimate.

67. We estimate that anti-ICBM defense would receive the higher priority, and that the USSR could probably develop a missile system of some capability against the ICBM for first operational use during the period 1963–66. We are unable to estimate with confidence the characteristics of such a system. It might carry a 1,000-pound payload to a horizontal distance of about 40 n.m. and an altitude of about 200,000 feet. An extension of these range and altitude capabilities would require advances in radar design which we believe are not within Soviet capabilities during this period. Such an anti-ICBM system might be modified for use against aircraft and cruise-type missiles up to altitudes of about 100,000 feet and to ranges of about 150 n.m. Development of antimissile defense systems will undoubtedly be continued beyond the period of this estimate.

Air-to-Air Missile Systems[19]

68. In late 1945 and 1946 the USSR acquired several German air-to-air missiles and designs. Although during this period German scientists in the USSR successfully applied Soviet solid propellants to German unguided rockets, we know of only one instance in which the Germans worked on a guided missile employing these propellants. This design was the German *Falke*, later given the Soviet designation *Sokol*. The *Sokol* was designed to have a solid-propellant rocket motor of 2,800 pounds thrust, an optical track-radio command guidance system, and an HE warhead of 106 pounds, to be detonated by either radio or acoustic proximity fuzing. The design study, excluding guidance, was completed by the Germans in 1948. We have no evidence that the USSR pursued any of the German work to completion, but there is a small amount of evidence to indicate that the USSR now has an air-to-air missile development program.

69. Despite the lack of significant intelligence in this field, we believe that Soviet air defense requirements would have dictated that the development of air-to-air missiles be given an initial high priority. This estimate is supported by some indirect evidence, including Soviet interest in infrared homing devices and the fact that the airborne intercept radar which has been developed for the FLASHLIGHT fighter could be used in conjunction with air-to-air missiles. We therefore believe that the USSR continued development work after 1948, and that by 1955 it could probably have had in operation a solid-propellant air-to-air missile capable of carrying a 25-pound payload to a range of 2–3 n.m., with a CEP of 30 feet. However, the passive infrared homing system probably employed in this missile would limit its use to tail-cone attacks under conditions of good weather at the engagement altitude.

70. The probable limitations of the above missile would have dictated high-priority efforts to develop an all-weather air-to-air missile, and we believe that in 1958 the USSR could probably have such a missile in operational use, employing a semiactive homing system and capable of carrying a 50-pound payload to a range of 5 n.m., with a CEP of 40 feet. In addition, the USSR will probably develop a longer range all-weather missile, and could probably have in operation in 1960 a missile capable of carrying a 150-pound payload to a range of 15–20 n.m., if launched at 60,000/ altitude. This missile could probably achieve

[19] Unguided rockets are not included in this estimate.

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a CEP of 50 feet, employing semiactive homing guidance, or infrared homing for tail-cone attacks.

Air-to-Surface Missile Systems

71. Complete design data on all German air-to-surface missiles were acquired by the USSR, as were many completed German missiles. The USSR also obtained information on German air launchings of the V–1. One German group at Design Bureau 2, Moscow, engaged in research and development work from 1947 to 1951 on a guidance system for a Soviet-designed antiship missile designated *Komet*. Details are not available on the design of its warhead, airframe, and propulsion system, although from information provided by the Germans who worked on the guidance system we have deduced general information concerning the over-all system performance. The TU–4 (BULL) was designated as the launching platform, and release of the missile was to be accomplished at about 10,000 feet altitude at a maximum range of 55 n.m. from the target. The missile speed was estimated to be about 485 knots. A radar in the launching aircraft was to provide for beam-riding during the first two-thirds of the missile's flight, and to illuminate the target for radar homing during the remainder of the flight. We believe that a missile system of the *Komet* type, or other air-to-surface system with similar performance characteristics, has reached at least final flight test stage.[20]

72. We therefore estimate that a subsonic air-to-surface missile, capable of delivering a 3,000-pound payload to a range of 55 n.m. from the launching aircraft, could probably be in operational use in the USSR in 1956–57. This missile, possibly employing beam-riding with semiactive terminal homing guidance, could achieve a CEP of 150 feet against ships or other isolated and well-defined radar targets. A supersonic missile to fulfill this requirement could probably be operational in 1958.

73. Although we have no evidence on other Soviet activities in the air-to-surface field, our estimate of Soviet military requirements leads us to believe that the USSR has probably also developed a shorter-range missile for employment against ships. It probably could have had in operation in 1955 a subsonic air-to-surface missile capable of delivering a 3,000-pound payload to a range of 20 n.m. A guidance system using television with a radio command link could probably achieve a CEP of 300 feet, but such a system could be employed only in good weather.

74. It is also probable that, in order to improve its long-range bomber attack capabilities against heavily defended land targets and large naval concentrations, the USSR will develop and could have in operation in 1961 a supersonic air-to-surface missile capable of carrying a 3,000-pound payload to a range of 100 n.m. The CEP of such a missile would vary with the type of guidance employed, ranging from about 0.5 n.m. with homing on a clandestine beacon to 1–2 n.m. with inertial guidance (assuming in the latter case that the launching aircraft could determine its own position within 0.25 n.m.).

Surface-to-Surface Missile Systems

Ballistic Missiles

75. After World War II, the USSR acquired from Germany a number of complete V–2 ballistic missiles, as well as component parts and production facilities. V–2's were test-fired at Kapustin Yar as early as the fall of 1947. During the period up until about 1950, several different groups of German missile specialists and engineers in the USSR devoted considerable effort to improve the V–2 system, increasing the thrust of its motor from 25 to 35 tons, and improving its accuracy. At the same time, a Soviet team attempted to increase its maximum range of about 200 n.m. to about 350 n.m.

76. German experts under Soviet direction also performed preliminary design studies for other ballistic missiles. In December 1948 they completed a design study for a missile designated R–10, to employ a 32-ton thrust motor and designed to carry a 2,150-pound payload to a range of 430 n.m.; this study actually represented the consolidation of a number of proposals for further improvement

[20] See Annex C (Limited distribution under separate cover).

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of the V–2. Beginning in the spring of 1949, they worked on detailed designs for a missile designated R–14, which was to be a single-stage missile, to employ a 100-ton thrust motor and to carry a 6,600-pound warhead to about 1,600 n.m. A series of feasibility studies was made for an R–12 missile, to be a staged missile carrying a 2,200-pound warhead to about 1,300 miles. The Soviet utilization of these studies is not known.

77. We believe that exploitation of the Germans, together with parallel and subsequent native efforts, enabled the USSR to make significant progress in the development of ballistic missiles of short and medium ranges after 1948. In addition to the 25- and 35-ton thrust rocket motors which were available at that time, we believe that a 100-ton thrust motor was successfully developed by 1953. As indicated in Section II, we also believe the USSR has high capabilities for development of guidance systems, warheads, and probably airframes for ballistic missiles. These estimates are supported by the extensive Soviet ballistic missile testing program which has been under way at Kapustin Yar.[21]

78. Based on the evidence cited above and in Annex C, we believe that the USSR has pursued the development of several surface-to-surface ballistic missile systems. A missile of 175–200 n.m. maximum range has been developed and could probably have been operational in 1954. It is probable that this missile employs a 25-ton thrust motor and could carry a 2,000-pound payload.[22] Using a combination of radar track-radio command and inertial guidance, a CEP of 1–2 n.m. could probably be achieved, and this could probably be improved to about 2,000 feet by 1955–57. A CEP of 1–2 n.m. could probably be achieved with a pure inertial guidance system by 1958–59.

79. In addition, a missile of about 350 n.m. maximum range has been developed and probably could also have been operational in 1954. It is probable that this missile employs a 35-ton thrust motor and could carry a 2,000-pound payload.[22] Using a guidance system similar to that of the 175–200 n.m. missile, this missile could probably achieve a CEP of 1–2 n.m., which could be improved to 3,000 feet by 1955–57. A CEP of 1–2 n.m. could probably be achieved with a pure inertial guidance system by 1958–59.

80. Development work has also been in progress on a missile of about 700 n.m. maximum range, which could probably have been operational in 1956. It is probable that this missile employs a 100-ton thrust motor and could carry a 6,000-pound payload. A guidance system similar to those of the first two ballistic missiles described could probably achieve a CEP of 3 n.m., improvable to 1–2 n.m. by 1957–59. A CEP of 1–2 n.m. could probably be achieved with a pure inertial system by 1958–62.

81. We have no firm evidence of Soviet development of any ballistic missile of shorter range than 175 n.m. We believe that a requirement exists for a missile with 75 n.m. maximum range for tactical support of ground forces, and for neutralizing certain additional targets, and that its relative ease of development would probably have led Soviet planners to include it in their program. We estimate that such a missile could probably have been in operation in 1954. Employing a 10-ton thrust motor, it could probably carry a 2,000-pound payload[22] and achieve a CEP of 1,200 feet, using a combination of radar track-radio command and inertial guidance. This CEP could probably be achieved with a pure inertial system by 1958–59.

82. Estimated Soviet requirements for improved attack capabilities against peripheral Eurasian targets and against the continental US lead us to believe that intermediate range and intercontinental ballistic missiles are probably under high priority development.

[21] For further details, see Annex C (Limited distribution under separate cover).

[22] The 2,000-pound payload weights given for the 75, 175–200, and 350 n.m. ballistic missiles described in paragraphs 78, 79, and 81 represent our basic estimates. However, we believe that if the USSR incorporated certain technically feasible refinement in structural design, these missiles could carry to their maximum ranges payloads weighing 1.5 to 2 times as much as those estimated. We have no evidence of such Soviet developments.

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These missiles are the logical goals of the step-by-step Soviet ballistic missile development program which was clearly under way by 1948. The R–14 studies ordered by the USSR in early 1949, as well as the R–12 studies, confirm an early Soviet interest in at least the IRBM. The significance of the R–14 studies is further increased by recent US experience, which indicates the feasibility of achieving ranges up to 1,600 n.m. with a single 100-ton thrust rocket motor. In view of probable Soviet requirements and the progress of the Soviet program to date, we estimate that the USSR is probably developing and could probably have in operation in 1959 a single-stage IRBM, capable of carrying a 1,650-pound payload to a maximum range of 1,600 n.m. A CEP of 3–4 n.m. could probably be achieved with a combination of radar track-radio command and inertial guidance, improvable to 1–2 n.m. in an additional one to two years, or in an additional three years with a pure inertial system.

83. In view of the potential capabilities of an IRBM against the continental US as well as overseas targets, if launched from a submarine, we believe the USSR may attempt to develop an IRBM for submarine employment. However, the formidable problems involved (including the development of pure inertial guidance, precise navigational equipment, and specially configured submarines with the necessary handling, fueling, and launching equipment) lead us to estimate that with a vigorous program the USSR might achieve an operational submarine-launched IRBM system some time during the period 1964–66.

84. There is no direct evidence that the USSR is developing an ICBM, but its development has probably been a high priority goal of the Soviet ballistic missile program. We estimate that the USSR now possesses, or is rapidly acquiring, the necessary data for attacking the aerodynamic, structural, and guidance problems of an ICBM. The solution of many problems, including the re-entry problem, has already been aided to some extent by the 700 n.m. ballistic missile development program, and should be further advanced by work on IRBM and earth satellite programs. It is therefore probable that the USSR could have ready for operational use in 1960–61 a prototype ICBM capable of carrying a 1,500-pound payload to a maximum range of 5,500 n.m. The high priority requirement for an operational ICBM would probably dictate the equipping of the first operational unit with prototype ICBMs. Such a missile would probably employ two 100-ton thrust motors for first-stage propulsion and one 35-ton motor for second-stage propulsion. With a combination of radar track-radio command and inertial guidance, a CEP of about 5 n.m. could probably be achieved, but an additional two years would probably be required to achieve this CEP with a pure inertial system.

Cruise-Type Missiles

85. Many German V–1 component parts and considerable manufacturing equipment were shipped to the USSR after World War II. Estimates on the number of V–1 missiles assembled in the USSR range from 50 to several hundred. German V–1 experts were exploited until about 1950; their work included projects to improve the V–1's guidance system and its pulsejet engine. The Germans reported that Soviet scientists experimented with twin-pulsejet V–1 type missiles in 1948 and 1949. Also, a German group prepared a preliminary design study for a ramjet cruise-type missile designated R–15, which was to be a 1,600 n.m. missile boosted to operating altitude and speed by a jettisonable V–2. However, no German ramjet experts were involved and there was no evidence of any Soviet interest in this project after the completion of the design study in December 1949.

86. The postwar work on pulsejet missiles, while far less extensive than work in other guided missile fields, could have permitted the USSR to have improved V–1 type missiles in operational use by 1950. However, because of the apparent lack of Soviet interest and the limited speed and altitude capabilities and high fuel consumption of pulsejet motors, we believe that the USSR probably did not carry development of such missiles to completion.

87. The potential military value of submarine-launched surface-to-surface missiles, to-

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gether with the difficulty of employing ballistic missiles with submarines, would probably have led the USSR to develop cruise-type missiles initially. There is some evidence, as yet inconclusive, of the existence of Soviet submarines equipped to carry such missiles. Based on estimated Soviet requirements and capabilities, we believe that the USSR has probably developed and probably could have had in operation in 1955 a submarine-launched turbojet missile capable of carrying a 3,000-pound payload at high subsonic speeds to a maximum range of 500 n.m. The accuracy of this missile would probably vary from 0.5 to 10 n.m., depending upon the guidance system employed and the accuracy with which the guidance submarine could fix its position.

88. A supersonic missile to fulfill this requirement could probably be in operation in 1957. Guidance could probably be improved to obtain a CEP of 1–2 n.m. at maximum missile range in 1960, using an inertial guidance system monitored by radar map-matching.

89. The requirement for submarine-launched missiles will probably lead the USSR to develop a longer range cruise-type system. A supersonic missile capable of carrying a 3,000-pound payload to a maximum range of 1,000 n.m. could probably be operational in 1962. As with the 500 n.m. missile, CEP's would vary considerably with the type of guidance employed.

Earth Satellite

90. In April 1955, the USSR announced the formation of the Permanent Interagency Commission for Interplanetary Communications. There is other evidence indicating the existence of this commission at least as early as the fall of 1954. The public announcement was the first official indication that the USSR was actively engaged on problems associated with the launching and orbiting of earth satellite vehicles. The six commission members named are among the leading Soviet scientists; their competence in such fields as astrophysics and nuclear research is internationally recognized. One of the first tasks of this commission was stated to be the organization of work for the creation of an "automatic" laboratory for scientific research of outer space. Since late 1955, numerous unofficial statements have been attributed to Soviet scientists concerning Soviet intentions to launch satellites during the International Geophysical Year (1 July 1957 to 31 December 1958). In September 1956, the Soviet IGY Committee announced its intention to participate in the IGY rocket and earth satellite programs. No detailed program was submitted, however.

91. The USSR will probably make a major effort to be the first country to orbit an earth satellite. On the basis of estimated Soviet guided missile capabilities, we believe that the USSR possesses the basic technical capabilities, skills, and other resources required to develop, build, and orbit an unmanned satellite vehicle. The successful orbiting of a satellite vehicle requires solutions for many of the scientific and technical problems encountered in the development of long-range ballistic missiles, except for the re-entry problem, and with the added requirement for a small, long-life power supply. We believe that the USSR has the capability of orbiting, in 1957, a satellite vehicle which could acquire scientific information and data of limited military value. A satellite vehicle possessing substantial reconnaissance capabilities of military value could probably be orbited in the period 1963–65.

Specialized Missiles

92. We consider that, during the period of this estimate, it will be within Soviet capabilities to develop specialized missiles for employment as decoys and antiradar weapons. We have not estimated specific Soviet programs among the wide range of possibilities in these fields. However, we believe that some of the air-to-surface missiles described in the preceding paragraphs could be modified to home on ground radars, and that a portion of the air-to-surface missile production estimated in Annex A might comprise these antiradar weapons.

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TABLE I

SOVIET GUIDED MISSILE DEVELOPMENT PROGRAM THROUGH 1966 [1]

SURFACE-TO-AIR MISSILE SYSTEMS

Designation [2]	First Operational Capability Date [3]	Maximum Altitude (ft.)	Maximum Horizontal Range (n.m.)	Accuracy (CEP in ft.)	Payload [4] (lbs. and type)	Maximum Speed (Mach No.)	Guidance	Para. Refer.	Remarks
Ground-Launched									
SA-1*	mid-1955	60,000	20 (1955) 25 (1957)	50 or 190	600–700 nuclear or HE	2.0–2.5	Command type (190′ CEP); mid-course command with terminal homing, probably semiactive (50′ CEP).	56–60	First operational capability simultaneous with decision to series produce. Characteristics are those estimated for early 1957.
SA-2	1958 [5]	40,000	15	50	150 HE	2.0	Semiactive homing	62	For low altitude defense.
SA-3	1959	80,000	50	100 or 500	500–800 nuclear or HE	3.0	Command type (500′ CEP); command with homing (100′ CEP).	63	
SA-4	1961	90,000	100	100 or 500	500 nuclear or HE	3.5	Command type (500′ CEP); command with homing (100′ CEP).	65	Alternate system also possible. See paragraph 65.
SA-5	1963–66	(Anti-ICBM System 200,000	40	1,200	1,000 nuclear	8.0	Command type	67	(Characteristics estimated are (subject to considerable error.
		(Modification for use against aircraft and cruise-type missiles 100,000	150	500	1,000 nuclear	7.0	Command with homing		
Ship-borne									
SA-6	1958	40,000	15	50	150 HE	2.0	Beam riding and/or semi-active homing.	64	(Could be modified for dual-(purpose use as surface-to-(surface missiles in appropri-(ate naval roles.
SA-7	1960	80,000	50	100 or 500	500–800 nuclear or HE	3.0	Command type (500′ CEP); command with homing (100′ CEP).	64	

[1] We evaluate this program as "probable," with varying degrees of confidence concerning detailed characteristics. See footnote to title of Section III. Those missile types for which our estimates are supported by significant current intelligence are indicated by an asterisk following the missile designation.

[2] These are arbitrary designations for convenience of reference. The same designations are used in Table II following Section I of Annex A.

[3] For definition, see paragraph 50.

[4] Payload includes the explosive device and its associated fuzing and firing mechanism. Warhead capabilities and requirements are discussed in Annexes A and D (the latter in limited distribution under separate cover).

[5] See Director of Intelligence, USAF, footnote to paragraph 62.

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TABLE I (Cont'd)

SOVIET GUIDED MISSILE DEVELOPMENT PROGRAM THROUGH 1966 [1]

AIR-TO-AIR MISSILE SYSTEMS

Designation [2]	First Operational Capability Date [3]	Maximum Range (n.m.)	Accuracy (CEP)	Payload [4] (lbs. and type)	Maximum Speed [5] (Mach No.)	Approx. Gross Weight (lbs.)	Guidance	Para. Refer.	Remarks
AA–1	1955	2–3	30 ft.	25 HE	2.0	175	Passive infrared homing.	69	Tail-cone attack in good weather.
AA–2	1958	5	40 ft.	50 HE	2.0	300–450	Semiactive homing.	70	All-weather.
AA–3	1960	15–20 if launched at 60,000′	50 ft.	150 nuclear or HE	2.0	800	Semiactive homing or infrared homing.	70	All-weather or tail-cone attack.

AIR-TO-SURFACE MISSILE SYSTEMS

Designation [2]	First Operational Capability Date [3]	Maximum Range (n.m.)	Accuracy (CEP)	Payload [4] (lbs. and type)	Cruise Speed (Mach No.)	Approx. Gross Weight (lbs.)	Guidance	Para. Refer.	Remarks
AS–1	1955	20	300 ft.	3,000 nuclear or HE	0.8–0.9	6,000–8,000	TV with radio command link.	73	For use in good weather.
AS–2*	1956–57	55	150 ft.	3,000 nuclear or HE	0.9	8,000–10,000	Beam riding with semiactive terminal homing.	72	For use against ships or other well-defined radar targets.
AS–3	1958	55	150 ft.	3,000 nuclear or HE	1.5	8,000–10,000	Beam riding with semiactive terminal homing.	72	Ditto.
AS–4	1961	100	0.5–2.0 n.m.	3,000 nuclear	2.5 max.	11,000	Command type, radar map-matching, or homing on clandestine beacon (CEPs of 0.5 n.m.); with inertial guidance, 1–2 n.m. CEP assuming launching aircraft can fix own position with 0.25 n.m.	74	For use against heavily-defended land targets or large naval concentrations.

[1] [2] [3] [4] See footnotes on page 21.

[5] Does not include speed of launching aircraft.

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TABLE I (Cont'd)

SOVIET GUIDED MISSILE DEVELOPMENT PROGRAM THROUGH 1966 [1]

SURFACE-TO-SURFACE MISSILE SYSTEMS

Designation [2]	First Operational Capability Date [3]	Maximum Range (n.m.)	Accuracy (CEP)	Payload [4] (lbs. and type)	Thrust of Motor (metric tons)	Approx. Gross Weight (lbs.)	Guidance	Para. Refer.	Remarks
Ballistic Missiles									
SS-1	1954	75	1,200 ft.	2,000 [5] nuclear, HE, or CW	10	12,000	Radar track-radio command/ inertial. Same CEP attainable with pure inertial system by 1958–59.	81	For tactical support of ground forces, and for neutralizing certain other targets.
SS-2*	1954	175–200	1–2 n.m. (1954) 2,000 ft. (by 1955–57)	2,000 [5] nuclear or CW, possibly HE	25	28,000	Radar track-radio command/ inertial. CEP of 1–2 n.m. attainable with pure inertial system by 1958–59.	78	Ditto.
SS-3*	1954	350	1–2 n.m. (1954) 3,000 ft. (by 1955–57)	2,000 [5] nuclear or CW	35	42,000	Radar track-radio command/ inertial. CEP of 1–2 n.m. attainable with pure inertial system by 1958–59.	79	Ditto.
SS-4*	1956	700	3 n.m. (1956) 1–2 n.m. (by 1957–59)	6,000 nuclear	100	110,000	Radar track-radio command/ inertial. CEP of 1–2 n.m. attainable with pure inertial system by 1958–62.	80	For peripheral attack; see paras. 23 and 27c.
SS-5 (IRBM)	1959	1,600	3–4 n.m. (1959) 1–2 n.m. (by 1960–61)	1,650 nuclear	100 (single stage)	150,000	Radar track-radio command/ inertial. CEP of 1–2 n.m. attainable with pure inertial system by 1962.	82	For peripheral attack.
SS-6 (ICBM)	1960–61	5,500	about 5 n.m.	1,500 nuclear	First stage, two 100-ton motors; second stage, one 35-ton motor.	300,000	Radar track-radio command/ inertial; same CEP attainable with pure inertial system by 1962–63.	84	First operational capability simultaneous with decision to series produce. For intercontinental attack.
SS-7 (IRBM)	1964–66	A submarine-launched IRBM system, with characteristics similar to those of the 1959 ground-launched system, might be available for operational employment some time during the period 1964–66.						83	

[1 2 3 4] See footnotes on page 21.

[5] These payload weights represent our basic estimates. However, if the USSR incorporated certain technically feasible refinements in structural design, these missiles could carry to their maximum ranges payloads weighing 1.5 to 2 times as much as those estimated. We have no evidence of such Soviet developments.

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TABLE I (Cont'd)

SOVIET GUIDED MISSILE DEVELOPMENT PROGRAM THROUGH 1966[1]

SURFACE-TO-SURFACE MISSILE SYSTEMS (Cont'd)

Designation[2]	First Operational Capability Date[3]	Maximum Range (n.m.)	Accuracy (CEP)	Payload[4] (lbs. and type)	Cruise Speed (Mach No.)	Approx. Gross Weight (lbs.)	Guidance	Para. Refer.	Remarks
Cruise-Type Missiles									
SS-8	1955	500	0.5–10.0 n.m.	3,000 nuclear	0.9	12,000	Radar track-radio command (CEP of 0.5 n.m. with forward guidance station within 100 n.m. of target; 1.0 n.m. with forward station within 200 n.m. of target); hyperbolic radio (CEP of 1–10 n.m.); combination of inertial guidance and homing on clandestine beacon (CEP of 1–2 n.m.); inertial system monitored by radar map-matching (CEP of 1–2 n.m. by 1960); pure inertial (CEP of 10 n.m. in 1955, with 2.5 n.m. at maximum range attainable by 1964, assuming submarine can fix own position within 0.5 n.m.).	87	Designed for submarine launching.
SS-9	1957	500	0.5–10.0 n.m.	3,000 nuclear	1.5–2.0	12,000	Same as 1955 subsonic missile.	88	Ditto.
SS-10	1962	1,000	1–10 n.m.	3,000 nuclear	1.5–2.0	25,000	Hyperbolic radio (CEP of 1–10 n.m.); inertial system monitored by radar map-matching (CEP of 1–2 n.m.). CEP of 5 n.m. at maximum range attainable with pure inertial system by 1964, assuming submarine can fix own position within 0.5 n.m.	89	Ditto.

[1 2 3 4] See footnotes on page 21.

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ANNEX A

A POSSIBLE SOVIET GUIDED MISSILE OPERATIONAL AND PRODUCTION PROGRAM

1. The program outlined in this Annex cannot be taken as the most likely or the probable Soviet program. We present it as only a possible program, but one which is both feasible and reasonable.[1]

I. POSSIBLE PROGRAM

2. We have direct evidence of the series production and operational deployment of only one of the 24 missile types discussed in Section III of the DISCUSSION. We have no knowledge of the actual Soviet program for production and employment of missiles during the next 10 years, and we could reasonably expect little direct evidence bearing on the problem. The range of possibilities is wide. In attempting to narrow this range, and to arrive at a better-defined judgment of the dimensions of the Soviet missile threat which will confront the US during the decade, we proceeded as follows: First, we estimated Soviet military requirements for numbers of missiles by type, making this estimate consistent with the date at which we believe each type could be available. These numbers were then modified in the light of: (a) the estimated availability of nuclear materials for warheads; (b) the estimated limitations of the Soviet economy, e.g., of the electronics and construction industries; and (c) an assumed Soviet desire to plan a reasonably economical program involving efficient production and an expenditure curve which would not move too sharply or irregularly and thus severely affect expenditures for other military programs.

3. In considering the numbers of missiles to be stockpiled, we have been unable to make definitive estimates of the Soviet view as to the effectiveness of missiles *versus* other weapons systems. We have, however, exercised judgment along the general lines indicated in Section I of the DISCUSSION as to the relative weight Soviet planners would give to particular missile types *versus* other available weapons to perform various missions. We do not believe that Soviet planners would at present be capable of realistically evaluating the effectiveness of their own as-yet undeveloped weapons systems. When such evaluations can be made, various aspects of any currently visualized Soviet program will be modified.

[1] It is the view of the Director of Intelligence, USAF, that the number of certain shorter range surface-to-surface and shorter range air-to-surface missiles projected in this estimate is in excess of any reasonable production in light of the limited availability of nuclear warheads and the limited requirement for HE and CW warheads. The number of missiles in these categories as shown in Annex A has been predicated mainly on the assumption that, although the Soviets recognize the desirability of having a high proportion of nuclear warheads (e.g., paragraphs 35 and 37 of Annex A) they would:

(a) Produce far more of these missiles than the number for which they could provide any significant percentage of nuclear warheads (paragraph 40 of Annex A and Table II, Annex A)

(b) Produce and use HE or CW warheads for the bulk of this large number of missiles (e.g., paragraphs 37 and 40 of Annex A)

(c) Plan for and be willing to accept the high cost and relative ineffectiveness of using a missile to deliver HE or CW on many military missions for which a nuclear warhead is highly desirable, if missiles are to produce the effects desired.

The Director of Intelligence, USAF, agrees that the USSR would indeed satisfy its requirements for missiles with HE and CW warheads, including reserve stocks, but believes that a shortage of nuclear materials would then limit the further production of missiles in these categories to the number for which nuclear warheads could be provided.

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4. This analysis is predicated upon our basic estimate that, barring unpredictable technological or political changes, there will be no specific war readiness target-date in Soviet military programs through this period. We have therefore not attempted to postulate what Soviet military planners would judge necessary to meet their full requirements for war readiness. We assume that the USSR will develop a missile force in-being consistent with Soviet judgments as to the effectiveness of missiles *versus* other weapons systems, that it will apportion its efforts according to the priorities of the various missions, and that it will stress the development and maintenance of production skills, experience, and facilities that can be expanded rapidly if necessary. We have not attempted to define the force in-being as optimum, maximum, or minimum, nor have we attempted to arrive at precise percentage requirements for air defense effectiveness or precise numbers of targets to be attacked by missiles.

5. Clearly the following paragraphs cannot be regarded as defining the most probable Soviet accomplishment over 10 years. There are far too many doubtful factors entering into the calculations; moreover, it is certain that any 10-year program of missile production envisaged now, whether by the USSR or by ourselves, will be subject to extensive change as the years go by. We believe, however, that these paragraphs set forth a program which, in the light of our uncertain knowledge at the present time, is not only possible but is also feasible and reasonable.

Warheads[2]

6. We have not attempted to estimate precisely what proportion of the stockpiles of various missiles would be provided with nuclear, HE, or CW warheads where such a choice would be feasible. We recognize, however, that the availability of nuclear materials will impose limitations on the extent of Soviet nuclear warhead production during the period of this estimate. In those cases where CEP's and payloads make HE or CW warheads feasible, we believe the USSR would produce such warheads in sufficient quantity to meet its requirements for certain specific missions, without regard to the availability of nuclear materials. However, we are unable to determine whether shortages of nuclear materials would in fact result in the production of fewer missiles of certain types than estimated herein, or in the production of additional HE or CW warheads, or both.

[2] See Section II of this Annex, and Annex D (the latter in limited distribution under separate cover).

Surface-to-Air Program

Ground-Launched

7. We estimate that the high priority almost certainly assigned to air defenses generally, together with the necessity for air defense weapons compatible with the requirements for defense against high-performance aircraft and missiles, probably gives surface-to-air missile defenses one of the highest priorities among current Soviet military programs. Observance of construction of the first of an estimated 57 launching sites around Moscow in 1953, some five years after the initiation of a native missile program, tends to confirm this estimate. Construction of the Moscow launching sites represented a major effort during the years 1953–56. On the basis of an estimated 60 launchers per site, and on allocation of four missiles per launcher, the missile stockpile requirement for the entire Moscow system would be about 14,000 missiles. Our estimate that large-scale production of these missiles is under way is supported by observations in 1955 and 1956 of four and possibly as many as six factory-type facilities near the city. These unique and almost identical facilities, at present in different stages of completion, appear to be partial fabrication and final assembly plants for surface-to-air missiles. At one of them, more than 450 missile-like objects were observed in September 1955.

8. Aside from the information presented above, plus some evidence that launching sites may be under construction near Leningrad, we have no intelligence on Soviet programs for the operational employment or production of surface-to-air missiles. We believe,

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however, that the surface-to-air program will continue to enjoy high priority. We believe that each surface-to-air system developed by the USSR will, with relatively minor improvements, possess combat utility for some five to seven years following the introduction of the succeeding system. In this manner, newer systems can either supplement older systems or permit their allocation to less critical static targets or to mobile units for defense of field forces.

9. Soviet military planners undoubtedly view the defense of Moscow as being of very high priority and of critical importance. They probably recognize that the current Moscow surface-to-air system will satisfy their requirements for only a few years. Available intelligence indicates that although the Moscow system has the advantage of a very high rate of fire, it imposes limitations on the sector covered by individual sites to about 60°, and a large number of sites are required to provide adequate all-around coverage. Because of these limitations and the great expense of the current installation in fixed facilities, we believe the surface-to-air missile defense as observed around Moscow to be a special case dictated by the special importance of Moscow to the USSR. We believe that the Moscow-type surface-to-air defenses as now constituted and in terms of the level of defense effort would not be deployed in any additional Soviet areas, except possibly Leningrad.

10. To provide surface-to-air missile defenses for other critical areas, several alternatives are open to Soviet planners. For example, a single ring of sites, comparable to the inner Moscow ring of 23 sites, could provide a relatively high level of defense at most defended areas. With the present YOYO guidance system, we believe that 12 sites would be required to give 360° coverage with acceptable overlap. On the other hand, we estimate that in 1957 the current system could probably be modified to incorporate a guidance system capable of 360° traverse. Such a system would have a lower traffic-handling capability, but it would have the advantage of permitting subdivision of the large fire-units of 60 launchers into smaller units, each with its own guidance system.

11. We have no intelligence to indicate whether the USSR will elect to defend a few critical areas at a high level of defense or, alternatively, a larger number of areas at a lower level of defense. In any case, we estimate that a logical program for the 60,000 ft./25 n.m. missile might involve the activation of 150 units by 1959. This would require a stockpile of about 36,000 missiles, to be produced in the period 1955–58.[3]

12. The low altitude capability estimated for the 40,000 ft./15 n.m. system which could probably become available in 1958[4] would make it a valuable weapon for augmenting the defenses of both critical areas and field forces. This low-altitude coverage would probably be required to supplement the later, more advanced high-altitude systems as well as the current 60,000 ft./25 n.m. system. The USSR might thus produce a stockpile of about 22,400 of these missiles in the period 1958–66, and activate about 350 units for their employment.[5] A portion would probably be assigned to critical static target areas and the remainder, employing mobile launchers, to field forces.

13. It is probable that the USSR would desire to defend a relatively large number of critical military installations and industrial areas with surface-to-air systems of the 80,000 ft./50 n.m. and 90,000 ft./100 n.m. types. The improved characteristics of these systems would permit a reduction in the number of units assigned to the defense of any given critical area. We estimate that a total stockpile of about 60,000 missiles of these two types might be produced between 1959 and 1963, and that a total of about 250 units might be activated.[6] Beginning in about 1959, missiles of the 60,000 ft./25 n.m. type would probably

[3] Calculation based on 60 launchers per unit, four missiles per launcher.

[4] See Director of Intelligence, USAF, footnote to paragraph 62 of the DISCUSSION.

[5] Calculation based on 16 launchers per unit, four missiles per launcher, with an allocation of 150 units to static defense and 200 units to field forces.

[6] Calculation based on 60 launchers per unit, four missiles per launcher.

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be phased out of the defenses of critical areas and be redeployed to less critical areas and field force units.

14. The numbers of interim anti-ICBM missiles and units which the USSR might have by 1966 is conjectural. The USSR might elect to stockpile several thousand as an ultimate objective, the exact number depending upon: (a) its estimate of the number of US ICBMs to be countered; (b) its estimate as to the net effectiveness of the system against ICBM's; (c) the number of nuclear warheads available for use in the anti-ICBM role; and (d) its estimate of the effectiveness of this system, as modified, against high performance bombers and cruise-type missiles. The uncertainties as to when such a weapon might be brought to first operational use (1963–66) precludes confident numerical estimates. On a tentative basis, we estimate that a reasonable number of missiles produced through 1966 might be 1,000 for use in the anti-ICBM role, and the number of units about 15.

Shipborne

15. While the defense of naval surface units would probably have a lower priority than the defense of key land targets, Soviet planners would almost certainly recognize that shipborne surface-to-air missiles could provide valuable protection for the Soviet surface fleet and decrease its dependence on shore-based aircraft. Considering these factors together with the economic cost of such a program, we believe the USSR might seek during the period of this estimate to equip about two-thirds of its cruisers and about one-sixth of its destroyer types with surface-to-air missiles. On the basis of estimated Soviet naval strength for 1961, and assuming a relatively constant force after that date, about 24 cruisers and 48 destroyer types might thus be equipped with surface-to-air missiles by 1966. A logical program might be as follows: (a) equip six cruisers and eight destroyer types with 40,000 ft./15 n.m. shipborne missiles, producing a stockpile of 1,500 such missiles between 1958 and 1961; [7] (b) later, equip 24 cruisers, including the six above, with 80,000 ft./50 n.m. shipborne missiles, producing a stockpile of 3,000 such missiles between 1960 and 1966; (c) equip an additional 40 destroyers with the 40,000 ft./15 n.m. missiles (including those withdrawn from the original six cruisers), the conversion of these destroyers and production of an additional 2,500 missiles to be accomplished by 1966.

16. *Warheads.* Nuclear warheads could be employed in any of the surface-to-air missile types estimated for the period except the 40,000 ft./15 n.m. types. While the small CEP's of most surface-to-air missile types would make HE warheads satisfactory, we estimate that the USSR would include nuclear warheads in some of these missiles. Such warheads would be mandatory for anti-ICBMs.

17. *Cost.* The ground-launched surface-to-air programs, involving the activation of about 750 static and mobile units and production of a stockpile of some 120,000 missiles, would cost an estimated 36 billion 1955 dollars in investment and operating expenditures through 1966. This represents about one-half of the dollar cost of the over-all missile program set forth in this Annex, and its dollar allocation is more than three times that of any other single category of missiles. The shipborne surface-to-air programs would entail investment and operating costs amounting to seven billion dollars, or about 10 percent of the over-all missile program.[8]

Air-to-Air Program

18. We have no evidence of any Soviet program for the operational employment or production of air-to-air missiles, but we believe that such a program has probably enjoyed a high initial priority as part of the over-all Soviet air defense effort. The Soviet air-to-air missiles which we estimate will probably be available during the first half of the period have several advantages which tend to counteract their guidance and payload limitations.

[7] All calculations based on four launchers per cruiser and two launchers per destroyer type, with an allowance of 30 missiles per launcher and a small allowance for reserve.

[8] For details of the estimated costs of the entire missile program, see Section III of this Annex. All dollar costs presented in this estimate are in 1955 dollars.

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These include: (a) their relatively cheap unit cost; (b) the availability of large numbers of fighter aircraft as carriers; and (c) their ability to improve fighter kill capabilities. Concurrent surface-to-air and air-to-air programs are justified during much of the period because of their complementary relationships. We believe, however, that late in the period the contribution of air-to-air missiles to the over-all Soviet air defense effort will probably decrease as the nature of the threat evolves.

19. We estimate that the USSR will continue to maintain about 9,300 fighter aircraft in operational units through at least 1961. Assuming an initial program to equip about one-fourth of these fighters with the currently available 2–3 n.m./good-weather air-to-air missile, a stockpile of about 20,000 missiles might be produced by 1958.[9] Soviet planners would probably consider this air-to-air system as an interim measure only, to be supplemented by the 5 n.m./all-weather air-to-air system which we estimate could probably be available in 1958. A Soviet program for this missile might involve full equipment of the 4,800 Soviet all-weather fighters estimated for 1961. Thus a stockpile of about 55,000 such missiles might be produced between 1958 and 1961.[10]

20. Soviet production of the 15–20 n.m. air-to-air missile, which could probably first be available in 1960, would probably be limited by the actual or impending threat of attack by cruise-type and ballistic missiles. However, since the 15–20 n.m. missile could carry a 150-pound payload, three times that of the 5 n.m. air-to-air missile and capable of employing nuclear as well as HE warheads, we believe some production would probably be undertaken. As a tentative figure only, we estimate that some 7,000 such missiles might be produced between 1960 and 1963.

21. *Cost.* The air-to-air programs described would entail an investment and operating cost amounting to about seven billion dollars, or 10 percent of the total cost. The entire air defense missile program, including surface-to-air and air-to-air missiles of all types, comprises approximately 70 percent of the dollar cost of the over-all Soviet missile program set forth in this Annex.

Air-to-Surface Program

22. While there is considerable evidence to indicate Soviet interest in air-to-surface missiles and we believe that one type has reached at least final flight test stage, there is no evidence of Soviet series production in this missile category. Our belief that such a program would probably be undertaken rests primarily on two factors: (a) Soviet planners probably estimate that they face a serious threat from US and Allied carrier task forces and that the capabilities of these task forces to defend themselves against close-in attacks by aircraft are already high and will continue to improve; and (b) they probably estimate that as the period advances, the capabilities of their own bombers to penetrate the defenses of key Western land targets will materially decrease.

23. Until 1961, the air-to-surface missiles available to the USSR will probably be those designed primarily as antiship weapons. A Soviet program for these missiles might be as follows: (a) on an interim basis, produce by 1958 a stockpile of about 1,000 [11] subsonic air-to-surface missiles, of which the majority might be 55 n.m. missiles of 8–10,000 pounds gross weight, and a portion might be 20 n.m. missiles of 6–8,000 pounds gross weight; (b) replace this stockpile with the supersonic 55 n.m. missiles which could probably be available in 1958, producing a stockpile of 1,000 [11] by 1960. Such a program could provide air-to-surface missiles for employment by 300 or more aircraft,[12] most of which would be of medium bomber or larger types. Some 55 n.m. missiles could be employed against

[9] [10] Calculations based on four missiles per aircraft per sortie, with sufficient 2–3 n.m. missiles available for two sorties per aircraft and sufficient 5 n.m. missiles for three sorties per aircraft.

[11] The Director of Intelligence, USAF, believes that the numbers of shorter range air-to-surface missiles shown here are excessive. See his footnote to paragraph 1 of this Annex.

[12] Calculation based on one missile per aircraft per sortie, with sufficient missiles for three sorties per aircraft.

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land targets, although the guidance system estimated for these missiles would limit their employment to isolated and well-defined radar targets and the short range would also limit their utilization. HE warheads would probably be satisfactory for employment against single ships, but nuclear warheads would be employed against land targets and ship concentrations.

24. The supersonic 100 n.m. missile of 11,000 pounds gross weight, which could probably be available in 1961, would increase the capabilities of manned heavy bombers to attack well-defended land targets, and could decrease the vulnerability of these aircraft. A Soviet program for these missiles might involve production of a stockpile of about 1,000 by 1966. Because of their CEP's payloads and probable employment, these missiles would require nuclear warheads.

Surface-to-Surface Program

Ground-Launched

25. Information from returned German personnel, as well as the large-scale testing of ballistic missiles in the USSR, indicate that at least experimental or pilot-line production has been under way for six to eight years, and that there must be at least one major assembly facility committed to such production.[13] Other than this circumstantial evidence, we have no knowledge of any Soviet program for the production or operational employment of ground-launched surface-to-surface missiles.

26. In estimating possible Soviet stockpiles for ground-launched surface-to-surface missiles, we have considered the different priorities the USSR would probably assign to missiles for augmenting or replacing other weapons systems in the tactical support, peripheral attack, and intercontinental attack roles,[14] and weighed these priorities against the requirement for economy in expenditure and in utilization of nuclear materials. While we have generally equated the stockpiles of certain missiles to numbers of operational units and targets to be attacked, the stockpiles themselves were not derived by any precise calculation of these factors. The stockpiles represent a time-phased program designed to achieve a reasonable degree of readiness and an expandable production capability. This we have done in the belief that Soviet planners must make contingent decisions when technology and doctrine are changing rapidly and comparative evaluation of competing weapons systems is not clear-cut.

27. *Short-Range Ballistic Missiles (up to 350 n.m. range)*

a. Because of its relatively low priority within the missile program, a production program for 75 n.m. ballistic missiles would probably be phased over a fairly long period. A stockpile of about 9,000 [15] such missiles might be produced between 1954 and 1960, with stress on maintaining an expandable production capability. This stockpile could equip about 90 missiles units.[16] The estimated 1,200-foot CEP of this missile would permit use of nuclear, HE, or CW warheads against appropriate targets.

b. On the same basis, a stockpile of about 3,000 [15] ballistic missiles of 175–200 n.m. range might be produced between 1954 and 1960. This stockpile could support about 30 units. A basic requirement exists for nuclear warheads. The estimated 1954 CEP of 1–2 n.m. would probably preclude the use of HE but not CW warheads, and would limit employment of these missiles to static targets. With a CEP improved to 2,000 feet by 1955–57, the use of HE would be feasible for some operations.

c. To provide an improved capability for attack against NATO or other forces, the USSR might have produced a stockpile of about 700 [15] ballistic missiles of 350 n.m. range between 1954 and 1956. This stockpile could support about 14 units. [17] The same warhead

[13] See Annex C (Limited distribution under separate cover).

[14] As set forth in Section I of the DISCUSSION.

[15] The Director of Intelligence, USAF, believes that the numbers of short range surface-to-surface missiles shown here are excessive. See his footnote to paragraph 1 of this Annex.

[16] Calculation based on 100 missiles per unit. Units assumed to have four launchers each.

[17] Calculation based on 50 missiles per unit. Units assumed to have two launchers each.

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and target limitations would apply as in the 175–200 n.m. missile, except that the use of HE would not be practicable.

28. *Ballistic Missiles of 700 n.m. and 1,600 n.m. Ranges.* Ballistic missiles of 700 n.m. range could reach much of the Eurasian land mass, Japan, Alaska, and a portion of the UK from launching sites within the Sino-Soviet Bloc. IRBMs of 1,600 n.m. range could cover these same targets from more secure launching sites and could extend the coverage to include more distant target areas. While we have not fully assessed the number of targets the USSR might elect to attack by this means rather than by other weapons systems, we estimate that the USSR might stockpile about 900 of these missiles. We have assumed that the advantages the USSR could gain by acquiring a missile capability in-being for attack on Western Europe would probably lead it to produce the stockpile fairly rapidly. We have thus allocated the larger portion of the stockpile to the 700 n.m. missile because of its earlier availability, and on this basis we have assumed a stockpile of 700 ballistic missiles of 700 n.m. range produced between 1956 and 1960 and a stockpile of 200 IRBMs produced between 1959 and 1962. We recognize, however, that the earlier program might be cut back to allow some increased production of IRBMs. The CEP's, payload weights, and probable employment of both the 700 n.m. missile and the IRBM would require nuclear warheads, although we do not exclude the possibility of CW use with the 700 n.m. missile for occasional special missions.

29. *Intercontinental Ballistic Missiles (5,500 n.m. range).* We believe that the USSR will seek to acquire a considerable number of ICBMs with nuclear warheads as rapidly as possible. In reaching this conclusion we have considered: (a) the great potential military value of the ICBM as compared to competing Soviet weapons systems, particularly for surprise attack; (b) the military advantage the USSR could gain if it could acquire a substantial ICBM capability before the US had developed adequate countermeasures or similar forces in-being; (c) the potential economy of the ICBM system as compared to competing weapons systems; and (d) the probable low initial system reliability and accuracy of the ICBM. On these grounds, a Soviet ICBM program might include production of a stockpile of about 1,000 missiles between 1960 and 1965.[18] To provide security and permit rapid rates of fire, but at the same time to conserve investment in facilities, the USSR might employ about 100 widely dispersed ICBM launching sites, each with 10 missiles and two launching pads, although many other methods of deployment would be possible.

Shipborne

30. Any of the present Soviet submarine types could be equipped to carry one or two cruise-type missiles in topside stowage, and conventional-powered or nuclear-powered boats about the size of the "Z" class could be converted or constructed to accommodate four missiles each in internal stowage. While there is no evidence to indicate how many guided missile submarines the USSR intends to convert or construct, we estimate that it could now have about 10 submarines equipped to carry missiles in topside stowage. Its future program might call for the construction or conversion of about 50 submarines with internal stowage by about 1966.

31. We estimate that production of surface-to-surface cruise-type missiles is probably under way, and that a Soviet production program might be as follows: (a) to acquire an initial capability rapidly, produce a stockpile of 100 missiles with 500 n.m./subsonic capabilities between 1955 and mid-1957; (b) produce a stockpile of 150 missiles with 500 n.m./supersonic capabilities in the period 1957–60; (c) produce a stockpile of 300 missiles with 1,000 n.m./supersonic capabilities in the period 1962–64, in part to replace the subsonic missiles and in part to equip submarines converted or constructed after 1960. The CEP's, payload weights, and probable employment of these missiles would require nuclear warheads.

[18] These dates assume first operational capability of the ICBM at the earliest probable date (i.e., the beginning of 1960). Within range of our estimate, however, a Soviet ICBM might not be operationally available until the end of 1961.

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32. The USSR might also adapt 80,000 ft/50 n.m. shipborne surface-to-air missiles to permit their alternative use against surface targets in appropriate naval roles. The basic numerical requirement for such missiles is included in the shipborne surface-to-air program (paragraph 15 of this Annex).

33. *Cost.* The estimated investment and operational cost of the entire surface-to-surface program is about 20 billion dollars, or approximately 27 percent of the dollar cost of the over-all missile program. The included ICBM program represents about eight percent of the over-all program.

Table II, summarizing Section I of this Annex, begins on page 33.

II. WARHEAD CONSIDERATIONS AFFECTING POSSIBLE PROGRAM

Nuclear Warheads

34. The production and operational program for guided missiles described in Section I of this Annex has been assessed in the light of the estimated availability of nuclear materials to the USSR during the period. [19] The accuracy of the assessment is necessarily limited by the element of uncertainty in our estimates of past and future Soviet production of fissionable materials. [20] It is further limited by our inability to determine with any validity the planned Soviet allocation of fissionable materials available for weapons.

35. From the standpoint of destructive effect alone, a probable Soviet objective would be to allocate nuclear warheads to a large percentage of all those missiles for which it is technically possible to design such warheads. It is highly unlikely that sufficient nuclear materials will be available during the period of this estimate to permit such an allocation.

36. We have not made an estimate of the amount of fissionable material which the USSR would allocate to guided missile use. Nor have we estimated the percentage allocation of nuclear warheads to all the various missiles. However, in order to assess the limitation imposed by the availability of nuclear materials, we have selected those missiles which, because of their probable employment and/or CEP's, we believe would be equipped almost entirely with nuclear warheads, and have assumed that they would be 100 percent so equipped:

a. all submarine-launched surface-to-surface missiles (total: 550);

b. all 700 n.m. ballistic missiles, IRBMs, and ICBMs (total: 1,900);

c. all surface-to-air missiles employed as anti-ICBMs (total: 1,000);

d. all 100 n.m. air-to-surface missiles (total: 1,000).

Calculations based on Soviet weapons capabilities show that the USSR could equip all of these missiles with nuclear warheads, by allocating to the missile program about 55 percent of the U–235 and about 30 percent of the plutonium which has been estimated in NIE 11–2–56 to be available for weapons on a cumulative basis through 1966. [21] [22]

37. It is clear that if during this period the USSR equipped with nuclear warheads the long-range surface-to-surface ballistic missiles, submarine-launched missiles, anti-ICBMs, and long-range air-to-surface missiles postulated in this Annex, it would have to equip the large

[19] See NIE 11–2–56, The Soviet Atomic Energy Program, 8 June 1956 (Limited distribution). This estimate will be superseded by the forthcoming NIE 11–2–57.

[20] The uncertainty in our estimate of cumulative Soviet production of U–235 up to the present probably does not exceed plus or minus 50 percent of the estimated value and plutonium plus or minus 25 percent. The error in our estimates of future production is less predictable.

[21] The Director of Naval Intelligence did not concur with the figures in NIE 11–2–56 for the estimated production of U–235, and for the estimated production of plutonium after 1959, which were used as a basis for the calculations in this estimate. The Director of Naval Intelligence believes the figures to be too high, and that for planning purposes a more practical magnitude of cumulative quantities of U–235 would be in a range below that of the minus 50 percent lower limit of the estimates in NIE 11–2–56.

[22] For further details, see Annex D (Limited distribution under separate cover).

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TABLE II

A POSSIBLE SOVIET GUIDED MISSILE OPERATIONAL AND PRODUCTION PROGRAM THROUGH 1966

The program outlined in this table cannot be taken as the most likely or the probable Soviet program. We present it as only a possible program, but one which is both feasible and reasonable.[1]

Designation[2]	First Operational Capability Date[3]	Identifying Characteristics[4]	Stockpile Goal	Status of Stockpile at End of Year (Cumulative)[5] 1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Operational Units	Remarks
SURFACE-TO-AIR, GROUND-LAUNCHED																		
SA-1	mid-1955	60,000'/ 25 n.m. (1957 characteristics)	36,000	—	1,000	10,000	23,000	36,000									150 units activated 1955–59.	Static defense of critical areas.
SA-2	1958[6]	40,000'/ 15 n.m.	22,000	—	—	—	—	1,000	3,800	6,800	9,900	12,900	15,900	18,900	22,000		350 units activated 1958–66, 150 for static defense and 200 for defense of field forces.	For low altitude defense.
SA-3	1959	80,000'/ (50 n.m. (	60,000	—	—	—	—	—	5,000	17,000	35,000	47,000	60,000				250 units activated 1959–63.	Replaces 60,000'/ 25 n.m. system in critical areas and defends additional such areas. Earlier system transferred to less critical areas and field forces.
SA-4	1961	90,000'/ (100 n.m.(																
SA-5	1963–66	Interim anti-ICBM	1,000	—	—	—	—	—	—	—	—	—	—	100	400	1,000	15 units.	Stockpile a tentative figure only. Production might begin as late as 1966.

[1] See Director of Intelligence, USAF, footnote to Annex A, paragraph 1.
[2] These are arbitrary designations for convenience of reference. The same designations were used in Table I following Section III of the DISCUSSION.
[3] For definition, see paragraph 50 of the DISCUSSION.
[4] For further details, see Section III of the DISCUSSION.
[5] These figures do not include missiles produced for testing and training. Stockpile goal, once reached, is in general maintained throughout the period.
[6] See Director of Intelligence, USAF, footnote to paragraph 62 of the DISCUSSION.

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TABLE II (Cont'd)

A POSSIBLE SOVIET GUIDED MISSILE OPERATIONAL AND PRODUCTION PROGRAM THROUGH 1966

The program outlined in this table cannot be taken as the most likely or the probable Soviet program. We present it as only a possible program, but one which is both feasible and reasonable.[1]

Designation[2]	First Operational Capability Date[3]	Identifying Characteristics[4]	Stockpile Goal	Status of Stockpile at End of Year (Cumulative)[5] 1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Operational Units	Remarks
SURFACE-TO-AIR, SHIPBORNE																		
SA-6	1958	40,000'/ 15 n.m.	4,000	—	—	—	—	100	300	700	1,400	2,100	2,800	3,500	4,000		6 cruisers equipped by 1960, 8 destroyer types equipped by 1961, 40 additional destroyer types equipped 1962–66.	
SA-7	1960	80,000'/ 50 n.m.	3,000	—	—	—	—	—	—	100	300	700	1,400	2,100	2,800	3,000	24 cruisers, including 6 above, equipped by 1966.	Replaces 40,000'/ 15 n.m. system on 6 cruisers originally equipped, and equips 18 additional cruisers. Earlier system transferred to destroyer types.
AIR-TO-AIR																		
AA-1	1955	2–3 n.m./ good weather	20,000	—	500	6,000	16,000	20,000									One-fourth of Soviet fighter force of 9,300 aircraft equipped 1955–58.	Interim system.
AA-2	1958	5 n.m./ all weather	55,000	—	—	—	—	2,000	18,000	44,000	55,000						4,800 all-weather fighters fully equipped by 1961.	Supplements 2–3 n.m./good weather system.
AA-3	1960	15–20 n.m.	7,000	—	—	—	—	—	—	300	2,400	5,600	7,000				All-weather fighters.	Stockpile a tentative figure only.

[1] See Director of Intelligence, USAF, footnote to Annex A, paragraph 1.
Footnotes 2–5 on page 33.

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TABLE II (Cont'd)

A POSSIBLE SOVIET GUIDED MISSILE OPERATIONAL AND PRODUCTION PROGRAM THROUGH 1966

The program outlined in this table cannot be taken as the most likely or the probable Soviet program. We present it as only a possible program, but one which is both feasible and reasonable.[1]

Designation [2]	First Operational Capability Date [3]	Identifying Characteristics [4]	Stockpile Goal	Status of Stockpile at End of Year (Cumulative)[5] 1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Operational Units	Remarks
AIR-TO-SURFACE																		
AS-2	1956-57	55 n.m./ subsonic	1,000 [6]	—	—	100	1,000										300 medium bomber or anti-shipping reconnaissance aircraft.	Production might not begin until 1957. Portion of stockpile might be 20 n.m. missiles (AS-1) which could have been available in 1955.
AS-3	1958	55 n.m./ supersonic	1,000 [6]	—	—	—	—	150	600	1,000							300 medium bomber or anti-shipping reconnaissance aircraft, *not* in addition to those above.	Replaces subsonic version.
AS-4	1961	100 n.m.	1,000	—	—	—	—	—	—	—	150	300	500	700	900	1,000	Heavy bombers.	For strategic attack against well-defended targets.
SURFACE-TO-SURFACE, GROUND-LAUNCHED (BALLISTIC)																		
SS-1	1954	75 n.m.	9,000 [6]	600	1,800	3,200	4,700	6,100	7,600	9,000							90 missile units.	For tactical support of ground forces, and for neutralizing certain other targets.
SS-2	1954	175-200 n.m.	3,000 [6]	200	600	1,100	1,600	2,000	2,500	3,000							30 missile units.	Ditto.

[1] See Director of Intelligence, USAF, footnote to Annex A, paragraph 1.

Footnotes 2-5 on page 33.

[6] The Director of Intelligence, USAF, believes that the numbers of AS-2, AS-3, SS-1, SS-2, and SS-3 missiles shown in this table are excessive. See his footnote to Annex A, paragraph 1.

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TABLE II (Cont'd)

A POSSIBLE SOVIET GUIDED MISSILE OPERATIONAL AND PRODUCTION PROGRAM THROUGH 1966

The program outlined in this table cannot be taken as the most likely or the probable Soviet program. We present it as only a possible program, but one which is both feasible and reasonable.[1]

Designation[2]	First Operational Capability Date[3]	Identifying Characteristics[4]	Stockpile Goal	Status of Stockpile at End of Year (Cumulative)[5] 1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Operational Units	Remarks
SS-3	1954	350 n.m.	700[6]	200	500	700											14 missile units.	Ditto.
SS-4	1956	700 n.m.	700	—	—	50	150	250	500	700							Not estimated.	For peripheral attack; see paras. 23 and 27c of the Discussion.
SS-5 (IRBM)	1959	1,600 n.m. (IRBM)	200	—	—	—	—	—	30	100	170	200					Not estimated.	Peripheral attack.
SS-6 (ICBM)	1960–61	5,500 n.m. (ICBM)	1,000	—	—	—	—	—	—	100	300	500	700	900	1,000		100 launching sites, 2 launching pads each.	Intercontinental attack. Production might not begin until the end of 1961.
SURFACE-TO-SURFACE, SUBMARINE-LAUNCHED (CRUISE-TYPE)																		
SS-8	1955	500 n.m./ subsonic	100	—	5	60	100										) 10 submarines) with topside) stowage plus) 20 submarines) with internal) stowage by) about 1960. 30) additional submarines with) internal stowage by about) 1966.	To acquire initial capability.
SS-9	1957	500 n.m./ supersonic	150	—	—	—	5	50	100	150								
SS-10	1962	1,000 n.m./ supersonic	300	—	—	—	—	—	—	—	—	40	120	200	280	300		Replaces subsonic missiles and equips additional submarines.

[1] See Director of Intelligence, USAF, footnote to Annex A, paragraph 1.
Footnotes 2–5 on page 33.
[6] See Director of Intelligence, USAF, footnote to page 35.

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majority of its other missiles with non-nuclear warheads. However, it would be highly desirable and most probable that some percentage of other missiles, particularly surface-to-air and shorter range air-to-surface and surface-to-surface missiles, would be provided with nuclear warheads. We are unable to postulate valid percentage allocations, and present the following only for illustration: if an additional 10 percent of the fissionable material accumulated through 1966 were allocated to these other missiles categories, about 700 surface-to-air and 500 air-to-surface and surface-to-surface missile warheads could be provided. The desirability of providing larger numbers of these missiles with nuclear warheads is equally apparent, but their competing demands could not be met without reducing the amount of fissionable materials allocated to some other part of the program. For example, the scale of the surface-to-air missile program postulated in this Annex is such that the USSR could not equip a major portion of these missiles with nuclear warheads, even by utilizing all the fissionable material available for weapons.

38. There are certain factors, however, which tend to offset the stringency of nuclear materials:

a. The USSR could gain some flexibility of utilization by developing interchangeable nuclear components for certain weapons systems employing these components.

b. Through technical advances after 1960 it will probably increase the explosive yield attainable from a given weight of nuclear materials and the economy of use of these materials in individual weapons.

c. Some missile types could be effective with other than nuclear warheads. Moreover, certain missiles for which we have assumed 100 percent nuclear warheads might for certain specific missions achieve acceptable effects with other types of warheads, or could employ nuclear warheads of lower yields than those we have assumed for the assessment in this Annex.

d. Finally, the possibility cannot be excluded that the USSR would deliberately plan to restrict its wartime employment of nuclear weapons under certain circumstances and in certain areas which it planned to occupy or exploit, in order to cause the minimum amount of physical damage.

39. Nevertheless, the USSR would face many difficulties in the allocation of fissionable materials to its various weapons systems during this period. It could mitigate these difficulties by phasing the equipping of certain missiles with nuclear warheads over a longer period of time, by producing smaller quantities of certain missiles during the period of the estimate, or by deliberately planning on the extensive use of non-nuclear warheads. We cannot estimate with confidence what the USSR will do in this respect, but we believe it might adopt some combination of these three courses of action.

40. We have not undertaken to estimate the probable basic Soviet allocation of nuclear materials as between the guided missile program and other uses. However, we believe that within a plausible basic allocation — assumed in this estimate as about 50 percent for the missile program — the USSR would be able to equip with nuclear warheads: (a) a very high proportion of the postulated production of missiles for which nuclear warheads would be regarded as essential (i.e., those types named in paragraph 36 of this Annex); and (b) a much smaller proportion of the postulated production of selected other missile types.

Chemical Warheads

41. There is no evidence of Soviet development of CW warheads for guided missiles. However, our estimate of Soviet capabilities to develop and produce agents and to solve the problems of dissemination by guided missiles leads us to believe that the USSR could have had tabun (GA) warheads by 1954 and could have had sarin (GB) warheads by 1956. Active Soviet military interest in CW is shown by the extent of their CW organization, the widespread issue of chemical defensive equipment, the extent of their training program for CW defense, and the statements of Soviet leaders. The USSR would probably consider CW warheads desirable for certain

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specific purposes: for attack on personnel in the open; for employment against personnel in areas where the USSR would wish to hold physical destruction to a minimum; and possibly for psychological effect.

42. On the basis of our estimates of Soviet CW agents available, missile warhead weights, and Soviet capability to develop the necessary munitions, we believe the USSR could achieve with GB agents a 50 percent casualty effect against unprotected personnel in the open over the following areas: [23]

Warhead Class	Area	Radius of Effects
2,000 lb.	1.3 sq. mi.	3,300 ft.
4,000 lb.	3.0 sq. mi.	5,100 ft.
6,000 lb.	8.0 sq. mi.	8,400 ft.

43. We estimate that the USSR could probably develop and employ "V" agents in guided missiles by 1960. This date is predicated on Soviet solution of the problem of generating a proper aerosol for dispersal of the "V" agent. Recent intelligence indicates that the Soviets have made substantial progress in aerosol generation, although no evidence is available to indicate its application to the dissemination of CW agents by guided missiles. Use of "V" agents, far more toxic than the "G" series, would enable the USSR to obtain area coverages approximately three times as great as those shown for the "G" series.

Biological Warheads

44. We estimate that antipersonnel BW agents which could now be available to the USSR are brucella, tularense, anthracis, and pestis. The means employed for CW dispersal by guided missiles could also be used for BW.

45. The use of antipersonnel BW agents would be profitable only in situations where delayed casualties are acceptable. Other than this, the advantages of using these agents in guided missile warheads would be generally similar to those of CW. However, greater quantities of BW agents could be disseminated over even wider areas by clandestine delivery and other means than by guided missiles.

46. We estimate that the USSR could also have certain anticrop and antilivestock agents which could be used in guided missiles.

III. ECONOMIC IMPLICATIONS OF POSSIBLE PROGRAM

Costing Methods and Limitations

47. The problem of estimating the costs of a Soviet guided missile program for a period extending 10 years into the future has many limitations. Because neither the US nor the USSR has had sufficient experience in the production of these new weapons systems, costs calculated at present cannot be considered as accurate estimates of the actual future costs of producing and operating the guided missile systems postulated. They are, however, adequate for distinguishing the economic differences between one missile system proposal and another. They are the type of estimates used by the US in planning its future missile programs and are similar in nature and reliability to those which might be used by Soviet planners in making decisions about their own future programs.

48. In the absence of firm data on Soviet missile characteristics, production methods, and cost of component parts, the program has been costed in dollars, using known or estimated production costs for the nearest US counterparts of the missile systems under consideration. Almost all the data employed reflect planning costs supplied by the US military services responsible for the various US counterpart missiles. These data have been applied to the stockpile levels and time schedules stipulated in Section I of this Annex, using analytical procedures consistent with standard weapons systems cost analyses. Ruble costs have been derived by applying known or estimated ruble-dollar ratios. [24]

[23] In determining area coverage, favorable conditions for agent dissemination are assumed. Soviet GA would be slightly less effective than GB.

[24] For purposes of analytical convenience, all dollar costs used in this estimate are calculated in 1955 dollars; all ruble costs are in 1951 rubles.

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49. Because it is necessary to know the direction of any bias in the estimated costs of the program, it was decided that where there was a choice of militarily acceptable approaches with differing costs, the one with the lower cost would be used. This type of choice was made on economic grounds, without further consideration of the relative military effectiveness or vulnerability of the costed system as opposed to others. Other decisions also made the estimated costs somewhat lower than they might actually be. Certain items necessary to the operation of the various guided missile systems have not been included in the cost calculations because they were not considered exclusively guided missile items. Among these exclusions are the costs of early warning and ground control intercept systems and the costs of aircraft and naval vessels which carry missiles. The costs of nuclear warheads were not included. Also specifically excluded from the estimated totals are investment in plants and industrial equipment to produce missiles, and expenditures on research and development. All these factors tend to give the over-all estimate of the cost of the postulated missile program a severe downward bias, and it should be considered as a minimum figure. Our best judgment of the degree of downward bias for the items which were included in the costs is that it is not greater than 20 percent and more likely falls between five and 15 percent.

Cost of Program

50. The program for the production and operational employment of guided missiles, as described in this Annex, would be a large and costly one. We estimate, however, that such a program is within the economic capabilities of the USSR, although it would necessitate an increasingly heavy economic allocation through at least 1961. The program would incur an aggregate cost of about 73 billion (1955) dollars, or about 400 billion (1951) rubles, during the 14-year period from 1953 through 1966. The aggregate dollar outlay for this program is apportioned among broad categories of missiles approximately as follows: total air defense program (including all surface-to-air and air-to-air systems), 70 percent; total ground-launched surface-to-surface program, 25 percent; air-to-surface program, 2 percent; submarine-launched surface-to-surface program, 3 percent. The ground-launched surface-to-air program would incur by far the largest dollar outlay of any single category, comprising about 50 percent of the total. The ICBM program would comprise about eight percent of the total dollar outlay. (See Figure 1.)

51. For purposes of analysis, the aggregate costs of the program have been broken down into broad areas termed "initial investment costs" and "annual operating costs." [25] In dollars, investment costs through the period represent about 44 percent of the aggregate cost of the program, with operating costs representing about 56 percent. (See Figure 2.)

52. The postulated program results in a fairly smooth but rapidly rising cost curve. Annual outlays in dollars rise from 0.5 billion in 1954 to 5.2 billion in 1959, and then rise sharply to about 8 billion in 1960, with annual expenditures ranging between 7.4 and 9.4 billion for the remainder of the period. Considering the entire period, about 20 percent of the total dollar outlay would be incurred through 1959 and about 80 percent between 1960 and 1966. The nature of the economic burden also shifts drastically from investment to operating costs as the period progresses. By 1966, nearly seven billion dollars per year are required to operate and maintain the missile systems which have been developed and produced during the period. (See Figure 3.)

[25] "Initial investment costs" are those one-time costs incurred in producing and activating a particular missile system, including missiles, installations, guidance and special equipment, organizational equipment, initial personnel training, and transportation. "Annual operating costs" are those additional recurring expenses incurred in the operation and maintenance of the equipment and personnel, including maintenance of installations and equipment, missiles fired for proficiency and tests, personnel pay, allowances and subsistence, and support command. Neither "initial investment costs" nor "annual operating costs" take into account those excluded costs factors described in paragraph 49 of this Annex.

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53. The cost of the missiles themselves is only a partial measure of the economic magnitude of the missile program. Missiles and spare parts would account for only 25–30 percent of the dollar outlay for each missile system, while the major part of the outlay would be for associated equipment, facilities, and personnel. Therefore, changes in the organizational structure and method of deployment described in Section I of this Annex would have a proportionally greater effect on the total cost of the program than would changes in the size of the missile stockpiles to be produced. The ICBM program provides a striking example of this phenomenon. We have postulated a stockpile of 1,000 ICBMs deployed on 100 sites (10 per site). However, if the same stockpile were deployed on the basis of one ICBM per site, the presently estimated cost would be increased by a factor of about 10.

54. In conjunction with earlier estimates of Soviet military expenditures through 1961, presented in Appendix B of NIE 11–4–56, the effects of the possible missile program on total Soviet defense spending can be roughly determined. Assuming that the total military expenditures estimated in NIE 11–4–56 would not change, the missile program's share would rise from some two percent in 1954 to about 24 percent in 1961, and would require some reduction in the nonmissile expenditures. If, however, the nonmissile expenditures remained as estimated, the addition of this missile program would require increases in over-all military expenditures, reaching as much as 17 percent in 1961.

Impact on Electronics Industry

55. While the demands of the missile program on the Soviet electronics industry would be quite heavy, we estimate that the program is within the growing capabilities of that industry. As indicated in the DISCUSSION, the estimated capacity of the Soviet electronics industry will probably limit its ability to support a varied and extensive missile program and also meet the competing demands of other Soviet military and essential nonmilitary programs until about 1958. The missile program described in this Annex places its heaviest demands upon the electronics industry in the years after 1959. For example, roughly 20–25 percent of the estimated dollar value of Soviet electronics output would have had to be allocated to the missile program in 1955 and in 1956. This allocation would rise to roughly 30–35 percent in 1960. These percentages take into account the large increase in the total value of electronics output called for in the Sixth Five-Year Plan. Assuming that approximately two-thirds of the dollar value of annual electronics output continues to be allocated to military programs, the missile program would require somewhat over half the military electronics allocation for 1960.

Research and Development Costs

56. Limited data, based on US experience, provides some measure of the research and development costs which would be incurred in a national missile program of the magnitude estimated in Section III of the DISCUSSION. We have not included such costs in our aggregate figures for the period because we have no basis for determining R and D costs chargeable to the development of those missile systems which would not materialize until after 1966. As an indication of probable R and D costs in the early years, we estimate that such costs would have climbed from about one billion dollars in 1953 to a peak of about 1.7 billion in 1957.

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FIGURE 1

Total Cost of Possible Missile Program, 1953–1966
By Category of Missile

	Billions of 1955 Dollars	Percent	Billions of 1951 Rubles	Percent
Surface-to-Air, Ground-Launched	35.8	49.4	196.1	49.3
Surface-to-Air, Shipborne	7.4	10.2	42.8	10.6
Air-to-Air	7.3	10.1	44.2	11.1
Air-to-Surface	2.4	3.3	14.1	3.5
Surface-to-Surface, Ground-Launched (up to and including 700 n.m.)	10.0	13.8	49.9	12.5
Surface-to-Surface, Submarine-Launched	2.2	3.0	11.1	2.8
IRBM	1.3	1.8	6.9	1.7
ICBM	6.1	8.4	33.8	8.5
	72.5	100.0	398.9	100.0

FIGURE 2

Total Investment and Operating Costs
of Possible Missile Program
1953–1966
By Category of Missiles

	Initial Investment Costs	Operating Costs	Total
	(Billions of 1955 Dollars)		
Surface-to-Air, Ground-Launched	15.5	20.3	35.8
Surface-to-Air, Shipborne	3.8	3.6	7.4
Air-to-Air	3.2	4.1	7.3
Air-to-Surface	1.4	1.0	2.4
Surface-to-Surface, Ground-Launched (up to and including 700 n.m.)	3.2	6.8	10.0
Surface-to-Surface, Submarine-Launched	1.0	1.2	2.2
IRBM	0.4	0.9	1.3
ICBM	3.2	2.9	6.1
	31.7	40.8	72.5

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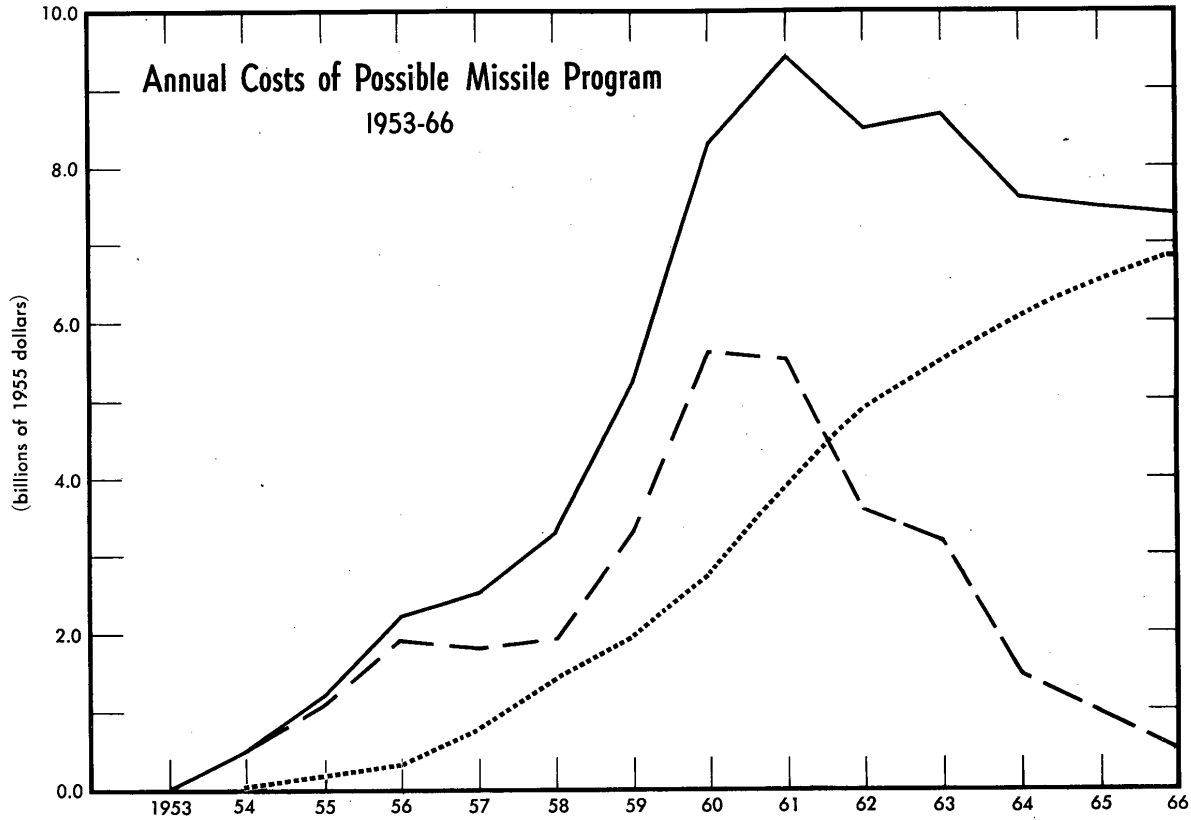
Figure 3



	1953	54	55	56	57	58	59	60	61	62	63	64	65	66
Total annual costs (billions of 1955 dollars)	—	.5	1.2	2.2	2.5	3.3	5.2	8.3	9.4	8.5	8.7	7.6	7.5	7.4
Investment costs	—	.5	1.1	1.9	1.8	1.9	3.3	5.6	5.5	3.6	3.2	1.5	1.0	.5
Operating costs	—	—	.1	.3	.7	1.4	1.9	2.7	3.9	4.9	5.5	6.1	6.5	6.9
Total annual costs (billions of 1951 rubles)	—	3.1	8.0	13.8	15.3	19.0	31.1	50.4	55.6	46.7	46.7	37.6	36.4	35.3

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ANNEX B

SOVIET SCIENTIFIC AND TECHNICAL RESOURCES FOR THE DEVELOPMENT OF GUIDED MISSILES

I. BASIC SCIENTIFIC CAPABILITIES

Scientific and Technical Personnel [1]

1. The rising general level of Soviet technical ability and the rapidly increasing number of Soviet scientists and engineers provide the manpower potential necessary to staff a very extensive guided missile program. Although total Soviet scientific resources remain smaller than those of the US, and assets of the Sino-Soviet Bloc far smaller than those of the West, the USSR has been able to achieve near parity with the US in areas of critical military and industrial significance. We estimate that the USSR as of mid-1956 had about 1,690,000 university graduates in scientific and technical fields, of which about 765,000 were actually employed in the physical sciences and engineering. If present trends continue, by 1961 the USSR could have 1,240,000 graduates employed in the physical sciences and engineering. While we know that in general the Soviet scientific effort has been focussed preponderantly on the building of a strong industrial base and the development of modern weapons, to the relative neglect of other fields, we have no firm evidence of the number of Soviet scientists and technicians working in the guided missile program.

2. The quality of Soviet scientific and technical personnel can be measured in fields other than guided missiles by evidence indicating striking progress over the past few years in such important fields as nuclear physics, geophysics, high-speed digital computers, high-temperature alloys, and the theory of automation. In basic research in mathematics and in many fields of physics and chemistry, the quality of the Soviet work is judged to be about equal to that of the US. In the missile field itself, the quality of Soviet personnel is revealed not only by known Soviet successes in developing surface-to-surface and surface-to-air missiles, but also by indications that by 1948 they were beginning to proceed with native development of missile components, independent of German missile experts.

3. *Research Equipment.* Although complex research instruments throughout the Soviet scientific program are probably in shorter supply than in the US, research and development programs of major importance, such as guided missiles, will probably be hampered only slightly by shortages or nonavailability of scientific instruments and equipment. Predicted Soviet advances by 1961 in electronics, which is basic to instrumentation, will probably permit the USSR to achieve near equality with the US in research instruments at that time.

4. *Materials.* We know of no shortage of basic materials required by the missile development program described in this estimate. Even though our information is practically nonexistent regarding specific application of materials to the guided missile program, the ability demonstrated by the USSR in developing unique materials for special application in other programs of complex nature leads us to conclude that materials for missiles will almost certainly not be unduly restrictive.

II. AVAILABILITY OF TECHNICAL KNOWLEDGE FROM FOREIGN SOURCES

5. *Exploitation of the German Missile Program.* At the close of World War II the USSR initiated a thorough and systematic exploitation of German guided missile personnel, facilities, and equipment. They obtained four general results: (a) the acquisition of operational and prototype missiles, research and production facilities and equipment, and ap-

[1] See NIE 11-6-56, Capabilities and Trends of Soviet Science and Technology, 9 October 1956.

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proximately 400 German missile specialists; (b) completed studies of German achievements prior to 1946; (c) the familiarization of Soviet personnel with German techniques of research, development, testing, and production of missiles and components; and (d) further technical studies and limited hardware development performed by German scientists. We believe that the Soviet exploitation program was an effort to acquire equipment and techniques in which the USSR had little or no experience. As a result of the foregoing exploitation, the Soviet personnel apparently acquired a thorough and valuable familiarity with the German program, and we believe that by 1948 the USSR had raised the level of its guided missile knowledge to that which had existed in Germany at the close of World War II. The repatriation of the German missile specialists began in 1950 and continued through 1953, with the exception of about 100 guidance and control specialists, some of whom have recently been repatriated. We believe, because of the deliberate separation of the Germans from the Soviet native missile program, that the German exploitation was utilized primarily for training, familiarization, comparison, and supplementary exploration.

6. *Availability of US Data.* A significant amount of potentially valuable knowledge on guided missiles and earth satellites has been, and is continuing to be, made available to the USSR in the form of unclassified Western publications. A definitive assessment of its value to the Soviet research and development program cannot be made. We do know, however, that enough unclassified information is available to provide the USSR with a relatively clear and accurate picture of the nature and extent of the US guided missile program, including relative priorities of systems and categories, developmental status, certain performance characteristics, and time schedules. While we cannot determine the degree of Soviet success in covert collection of information on foreign guided missile developments, we know of numerous instances during the past two years where the USSR has indicated through covert activities an interest in acquiring data on US missiles, particularly on air-to-air missiles, and missile electronics. There are no known instances of Soviet technical collection systems being specifically directed at, or developed for use against, US guided missile installations or facilities, although we believe that such surveillance is well within Soviet capabilities. Soviet interest in foreign missile programs is further attested by the fact that, in addition to their normal scientific translation and dissemination services, the USSR in 1950 began publication of the journal, "Problems of Rocket Techniques." This journal, publication of which has continued at least to mid-1956, contains translations of non-Soviet articles on guided missiles, earth satellites, and related subjects.

III. ORGANIZATION AND CONTROL OF THE SOVIET GUIDED MISSILE PROGRAM

Over-All Coordination and Control

7. The Soviet missile research and development program is conducted within the existing framework of ministerial functions and responsibilities. In 1947, over-all supervision and administration of the program was reliably reported to have been vested in a Special Committee of the Council of Ministers, which made policy and planning decisions. There is insufficient evidence to determine whether this Special Committee has been continued to the present. In addition, a Scientific and Technical Council (NTS) was described by a returned German scientist as the highest technical authority on guided missiles, with power to review Soviet-initiated German missile design proposals and to determine whether they should be continued into the development stage. The membership of the NTS was composed of military personnel, civilian research and development personnel, and scientific personnel from the Academy of Sciences, and was chaired by the Director of NII 88, the principal known guided missile installation under the Ministry of Defense Industry. Whether the NTS was set up solely to direct the German activity or whether it also had an active part in the native program is not known. Information on the activities of the NTS does not exist later than 1949.

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8. Despite the lack of current intelligence identifying a top authority for the entire Soviet missile program, we believe a program of such magnitude and complexity would require high-level centralized control. Soviet defectors have speculated that any high-level Soviet missile authority would include representatives of the military, the government, and the Party. Thus, such an authority might include representatives of the Ministry of Defense, the Council of Ministers (including its Academy of Sciences), and the military directorate of the Party's Central Committee. Although this speculation appears reasonable, we have no direct evidence of the existence of such an authority.

9. We believe that within those ministries engaged in the missile program, coordinating and control groups probably exist at various levels. For example, it was reliably reported that at least until about 1950 a Seventh Chief Directorate existed in the Ministry of Defense Industry, with over-all responsibility for surface-to-surface and surface-to-air missile development.

Organizations, Installations, and Facilities

10. The following summary includes important organizations, installations, and facilities known or estimated to be involved in the Soviet guided missile research and development program, together with brief discussions of their known or estimated contributions to the program:

Council of Ministers

11. *Special Committee for Guided Missile Activities:* A knowledgeable Soviet defector has reported on such a committee as it existed in 1946. A high-level German returnee has also reported the existence of such a committee. No information concerning its activities beyond 1949 is available.

Ministry of Defense Industry

12. *Chief Directorate for Guided Missile Activities:* A high-level German returnee has reported that a Chief Directorate existed which was concerned with research and development of surface-to-surface and surface-to-air missiles. No information exists beyond 1950, but the continued existence of such a Chief Directorate within the Ministry of Defense Industry to control its missile research, development, and production activity is considered most likely.

13. *Scientific Technical Council (NTS) for Guided Missile Research and Development:* The existence during 1947–49 of an NTS concerned with missile design projects worked on at Scientific Research Institute (NII) 88 has been reported by German returnees. The known Soviet practice of employing similar technical councils at various levels (Ministerial, Directorate, Plant, Institute) for developments in other military fields strengthens the belief that a missile NTS for the Ministry of Defense Industry probably still exists.

14. *The "88 Complex," Kaliningrad:* This installation, comprising a plant and a research institute, is believed to be a major center for surface-to-surface ballistic missile research and development, an activity in which it was engaged from 1946 to at least 1954. Surface-to-air missile research and development was also conducted at this installation from 1946 to at least 1950.

15. *Branch 1 of Scientific Research Institute (NII) 88, Ostashkov:* This large, well-equipped installation was the major center for exploitation of some German guided missile specialists who were repatriated in 1952–53. German efforts were concerned with design studies of surface-to-surface and surface-to-air missiles. Certain key facilities, especially for liquid rocket propulsion research, are believed to be still engaged in the guided missile research and development program.

16. *Plant 456, Khimki:* Center for research and development of large, liquid-fuel rocket engines, staffed in part by Germans until 1950. Design work on a 100-metric-ton thrust engine was conducted here, as well as work on 25- and 35-metric-ton thrust engines. This installation is still active in the research and development program.

17. *Central Artillery Design Bureau, Kaliningrad:* This installation is probably the leading Soviet design bureau for new artillery

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weapons. In addition to its role in designing conventional artillery, it is believed to play a central role in the design of surface-to-surface and surface-to-air missiles.

18. *Naval Artillery Central Design Bureau, Leningrad:* Personnel of this organization were active in the reconstruction of German surface-to-air missiles in Germany during 1945–46. We believe this bureau would be the focal point of any Soviet naval work in missile developments.

19. *Design Bureau (KB) 2, Moscow:* German technicians were involved in the development of an air-to-surface missile guidance system from 1946 to mid-1950. Soviet continuation of this project at KB–2 is indicated to at least mid-1953. Beginning in 1951, one group of German specialists worked on a high-priority Soviet project to develop a new triaxial stabilizing system, probably for a surface-to-surface missile, and this system was flight tested between 1952–53. By 1954 approximately 40 complete systems were manufactured. In February 1951, another German group was assigned to a surface-to-air missile guidance project. Information on the German work on this project correlates with the characteristics of the Moscow surface-to-air missile system. German work on this and all classified projects was terminated by the end of 1953. While working at KB–2, the Germans assisted Soviet work on an air-to-air missile project, and reportedly discussed with Soviet scientists a surface-to-surface (shore-to-ship) missile project.

20. *KB–3, Putilovo:* Research and development of an air-to-air guided missile (*Sokol*) was conducted here by German specialists from 1946–48. Unguided solid rocket air-to-air and surface-to-air research and development has also been reported. This installation, believed still to be active in the guided missile program, is closely associated with the Sofrino test range which adjoins it.

21. *"Dyatlov's" Institute – NII 24, Moscow:* This installation is reported to have conducted native Soviet development of air-to-air missile designs parallel to the German activity at KB–3. Dyatlov's Institute is possibly identical with NII 24.

22. *Plant 393, Krasnogorsk:* Research and development activities here have included work on the German infrared missile homing system, *Juno.* This installation has also indicated a capability for the repair of cine-theodolites, essential to test range instrumentation.

23. *"Konoplev's Institute," Leningrad:* A facility in Leningrad, associated with a scientist named Konoplev, has reportedly conducted development work on ballistic missile guidance systems. Konoplev attended NTS meetings at the 88 Complex, Kaliningrad, during 1947–48, when the R–10 design proposals were reviewed. Konoplev was concerned with R–10 guidance matters.

24. *NII 6, Moscow:* Numerous awards to members of the staff of this institute indicate a capability for research and development in the field of solid propellants for rockets and/or guided missiles. A Soviet scientist from NII 6 was a member of a Commission of the Academy of Artillery Sciences which was established to evolve better colloidal gunpowders for rocket artillery.

25. *Plant 604, Moscow:* In 1947, Germans reconstructed V–2 fuzes at this plant. The equipment used was then shipped to "Pishchik's Institute," Leningrad, but a capability for continued missile fuze development is believed still to exist at Plant 604.

26. *"Pishchik's Institute," Leningrad:* In 1947, V–2 fuze assembly equipment was shipped from Plant 604 to an installation in Leningrad associated with an engineer named Pishchik. Supplementary information suggests that this installation may be either Plant 521 or a Branch of Central Design Bureau 22 (possibly NII 22). Central Design Bureau 22 and Plant 521 were active in fuze research and development during World War II.

27. *NII 13, Leningrad:* Numerous awards to and publications by members of the staff of this institute indicate a capability for research and development in metallurgy applicable to heat transfer problems in combustion chambers, or to warhead re-entry problems. This institute is specifically concerned with metallurgical research, notably in the fields of heat treatment of metals and nonferrous alloys.

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Ministry of Defense

28. *Chief Artillery Directorate, Moscow:* This organization is responsible for the over-all supervision and coordination of research, development, and manufacture of artillery and antiaircraft weapons systems for the Soviet armed forces. In its role as point-of-contact between the industrial ministries and the Ministry of Defense, the directorate probably serves as the key organization coordinating military requirements and acceptance testing with guided missile research and development.

29. *Academy of Artillery Sciences, Moscow:* The academy was established in 1946 to improve and promote artillery and ordnance research and development. Its organization is similar to that of the Academy of Sciences, USSR, and it has an unknown number of associated research institutes. We believe the academy has an advisory role in the formulation of military requirements for guided missiles.

30. *Artillery Institute, Bolshevo:* This institute, possibly subordinate to the Academy of Artillery Sciences, is known to have been concerned with missile guidance and control research and development in the 1949–51 period. During that period, the institute was associated with both NII 88 and NII 885.

31. *NII of the Air Forces, Shchelkovo:* This institute is responsible for acceptance testing of all new aircraft. A high-level defector has described a directorate of this institute which was responsible for air-to-air rockets and, presumably, missiles. In addition, there are indications that the institute has conducted developmental work on various airborne weapons systems.

32. *Aviation Technical Commission of the Air Forces, Moscow:* This commission directs all scientific matters of concern to Soviet air forces research establishments under the Chief Engineer of the air forces. In its role as scientific adviser to the air forces, it examines all new projects and indicates lines of research on outstanding aeronautical problems. We believe, therefore, that this commission participates in the planning of research and development for those guided missiles to be used by the air forces.

33. *Air Forces Engineering Academy im. Zhukovskiy, Moscow:* This academy is the most important center for the training of aeronautical engineers in the USSR. Several members of the staff have been definitely associated with guided missile research and development, although not necessarily in their role as professors at the academy.

Academy of Sciences

34. *Interagency Commission for Interplanetary Communications:* This commission is believed to be the focal point for research and development pertinent to the Soviet earth satellite program. Key members of the staff are world-recognized authorities in scientific fields essential to such an activity.

35. *Institute of Automatics and Telemechanics, Moscow:* This institute is the Soviet center for fundamental and applied research in the fields of automatic regulation, remote control, telemetry, and nonlinear mechanics, and for the development of pneumatic, hydraulic, and electrical servo systems. It has been directly associated with missile guidance research and development activity at Branch 1 of NII 88.

36. *Institute of Precision Mechanics and Computer Engineering, Moscow:* This institute is a center for theoretical investigation and development of electronic digital and analogue computers, and has performed research and development on electrical and mechanical integrators, and network and differential analyzers. In addition, the institute is responsible for general theoretical problems of precision mechanical and electrical systems.

37. *Institute of Chemical Physics, Moscow:* This institute, the center for combustion research in the USSR, has conducted much basic research directly applicable to the development of both liquid and solid rocket engines. Other work, as indicated by open literature publications, could have been in the theory and development of techniques of shock-tube (hypersonic) experimentation.

38. *Institute of General and Inorganic Chemistry, Moscow:* This institute has conducted research in metallurgy, specifically in heat-resistant alloys, applicable to both rocket en-

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gine components and warhead materials. Other research has been on oxidants and fuels, particularly on nitrogen-containing compounds.

39. *Institute of Mathematics im. Steklov, Moscow:* This institute is responsible for fundamental research in mathematics. It has studied problems in the statistical theory of turbulent flow, which is directly applicable to the development of hypersonic configurations.

40. *Institute of Physics im. Lebedev, Moscow:* This institute, in addition to its work in acoustics and dielectrics, has given particular attention to the study of the diffusion of electromagnetic radiation.

Ministry of Aviation Industry

41. *Central Aerohydrodynamics Institute (TsAGI), Ramenskoye:* This is the primary Soviet center for aerodynamic research. This institute is a known participant in the Soviet guided missile research and development program. Specifically, it has conducted wind tunnel experiments for NII 88.

42. *NII 1, Moscow:* Numerous scientists and engineers who were on the staff of this institute in 1945 have since appeared in key positions in guided missile research and development centers. Research and development in the field of gas dynamics is believed to be the major activity of the institute.

43. *Flight Test Institute, Ramenskoye:* This installation is responsible for all Ministry of Aviation Industry research and development which requires flight testing. It is believed that the institute conducts tests of all airborne guided missile weapons systems prior to their submission to the Ministry of Defense for acceptance testing.

44. *Experimental Plant 1, Podberezhe:* This was a German exploitation center from 1946 to 1952. Research and development on V–1's, air-to-surface, and possibly surface-to-air missiles was conducted. In addition, this plant has supplied NII 88 with cigar-shaped fuselages, wings, accelerometers, altimeters, and other equipment.

45. *Special Design Bureau 3 of Plant 2, Kuybyshev:* Germans at this installation conducted research and development on automatic pilots, triaxial gyroscopes, and V–1 steering mechanisms. During 1948, about 100 standard V–1 control systems were reportedly overhauled.

46. *Central Scientific Research Institute of Aviation Engines (TsIAM), Moscow:* This installation is concerned with research and development of aircraft engines. Reported facilities include four rocket engine test stands and sections dealing with new engine designs. Support could be provided in the research and development of ramjet and pulsejet engines.

47. *Central Scientific Research Institute of Aviation Fuels and Lubricants (TsIATIM), Moscow:* We believe this institute would contribute to the development of special fuels for cruise-type missiles and also to the development of special lubricants and hydraulic fluids for all types of missiles.

Ministry of Radio-Technical Industry

48. *NII 885, Novaya:* At this installation, Germans worked on the reconstruction and development of a ground guidance system, a doppler-velocity measuring system and telemetering equipment for the V–2. A special branch at Monino worked until 1950 on a radar-homing head project for a surface-to-air missile. Both Soviet and German specialists from NII 885 were at Kapustin Yar in 1947.

49. *NII 20, Moscow:* German specialists who visited this installation in the 1946–48 period have reported that the *Tonne* television missile guidance system was under investigation. A defector report covering the period 1948 to June 1949 indicates that the installation may have been moved to Kuntsevo, southwest of Moscow, and transferred to the Ministry of Defense Industry.

50. *NII 380, Leningrad:* This was a German exploitation center from 1948 to 1952. The installation is the primary Soviet television development center. A secret department at Lesnoy reportedly devoted considerable effort

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to the development of the *Tonne* television guidance system for air-to-surface missiles.

51. *Unidentified Installation, Odessa:* Military personnel from an unidentified installation in Odessa frequently visited the Secret Department of NII 38. The Odessa installation reportedly had received one set of the *Tonne* equipment. Subordination of this installation to the Ministry of Radio Technical Industry is conjectural.

52. *NII 108, Moscow:* This installation is believed to be the major Soviet center for the research and development of radar equipment. On this basis alone, we believe it is possibly involved in the development of radar for missile guidance systems. The subordination of this installation has not been verified.

53. *NII 160, Fryazine:* This installation is believed to be the major Soviet electron tube design center. As such, it is probably involved in the development of missile electronic guidance equipment.

Ministry of Chemical Industry

54. *State Institute of Applied Chemistry (GIPKh), Leningrad:* This installation has conducted research on propellants, with emphasis on amine compounds for use in hypergolic fuels. Research on ignition properties of liquid propellants has also been reported. The activities of this installation have paralleled those of the Karpov Institute.

55. *Physico-Chemical Institute im. Karpov, Moscow:* Germans at this installation from 1946 to 1948 worked on hypergolic rocket fuels and hydrogen peroxide oxidizers. This installation is believed to be part of a complex including the State Institute of Applied Chemistry, Plant 94, and the OKA Chemical Plant, all of which have conducted rocket fuel research.

56. *OKA Chemical Plant, Dzerzhinsk:* Germans from the Karpov Institute were transferred to this installation in 1948 to continue their propellant research. A pilot plant for hypergolic fuels, developed at the Karpov Institute, was sent to OKA. Certain specialists employed here were reportedly subordinate to Plant 94.

57. *Plant 94, Moscow:* Hypergolic fuels developed at the Karpov Institute were sent here for testing. In addition, certain amines developed at the Karpov Institute were reportedly put into pilot production here.

Ministry of Machine and Instrument Building

58. *"Kompressor" Plant, Moscow:* Germans who were at this installation in 1947 have reported the development of V–2 type ground handling equipment.

Ministry of Heavy Machine Building

59. *"Pod'emnik" Plant, Moscow:* It has been reported that V–2 transporters were under development here. This installation is well equipped to develop such transporters.

Ministry of Shipbuilding Industry

60. *NII 49, Leningrad:* This installation has been engaged in the design and limited production of control devices, computers, gyroscopes, electronic test equipment, radar, and high-frequency apparatus. German specialists working here developed computers for surface-to-air missiles and worked on gyrostabilized platforms for inertial guidance systems. *Wasserfall* computers developed here were tested, possibly at Kapustin Yar, in 1949. This installation may have become one of the largest Soviet design institutes when it was enlarged in 1952.

61. *Kuznetsov's Gyroscope Institute, Moscow:* This installation appears to be a central agency for gyroscope research and development. The director, Kuznetsov, was in Germany in 1945–46 and at Kapustin Yar in 1947. There was close liaison between this installation and NII 885.

Ministry of Higher Education

62. Certain installations subordinate to this ministry, although properly educational institutions, are believed to conduct limited guided missile research at the graduate level. Several important guided missile specialists identified at key installations in the program have

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also been identified with the staffs of certain of these educational institutions.

63. *Higher Technical School im. Bauman, Moscow:* This institution is believed to be the "MIT" of the Soviet Union. A turbine assembly for the 100-metric-ton thrust engine developed at Plant 456 was reportedly sent here for testing in 1950.

64. *Power Engineering Institute im. Molotov, Moscow:* Another large engineering school, this institution possesses several faculties for subjects pertinent to guided missile research and development. At a 1950 conference, papers presented to the Instrument Building Section of the school were all of possible missile interest. Particularly, the paper presented by L. I. Tkachev appeared to be a classified version of his 1949 publication on an inertial system for missile guidance based on the 84-minute pendulum principle.

65. *State University im. Lomonosov, Moscow:* Although there is no direct evidence of guided missile activity at this institution, several key scientists and engineers of the guided missile program have been identified on the faculty.

Known Test Facilities [2]

66. *Kapustin Yar Guided Missile Test Range:* Established in 1947, as a missile test range, Kapustin Yar is the only identified surface-to-surface missile test range in the USSR. It is now known to be actively engaged in the testing of surface-to-surface ballistic missiles. The scale of effort involved indicates that Kapustin Yar is a most important facility in the Soviet program.

Suspect Test Facilities [2]

67. *Sofrino Test Range (SNIP):* This range, located adjacent to Design Bureau 3, is known to have actively supported the bureau in the past. On the basis of its limited size and general location, we believe the range may be concerned with the developmental testing of surface-to-air guided missiles only.

68. *Barents Sea:* There is some inconclusive evidence to indicate missile firings in this area. The location of a range in this area would be suitable for the shipboard testing of all types of guided missiles assigned to the Soviet Navy and for both environmental and operational testing of other missile types.

69. *Riga:* A facility at Riga is known to have received specimens of German naval air-to-surface missiles following World War II. Other than 1956 reports of a restricted coastal area in the Riga vicinity, there is no indication of present missile testing.

70. *Zagorsk:* German engineers at NII 88 designed a static test facility for large liquid rocket engines and surveyed a site in this area for its construction. No confirmation of its existence is available.

71. *Crimea (Black Sea):* Signals intercepted from the Crimea (Black Sea) area between May 1955 and September 1955 and in October 1956 are similar to guidance signals of an air-to-surface missile guidance system (Komet) designed at Design Bureau 2, Moscow. This comparison appears valid when considered with the report that Germans from KB–2 attended tests of this system in the Crimea at the end of 1951. Testing of surface-to-air missiles in the Crimea has also been indicated by the recent report that the surface-to-air missile project worked on at KB–2 was taken to the Crimea for tests beginning in November 1952.

[2] For further information, see Annex C (Limited distribution under separate cover).

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